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THERE will, apparently, be considerable progress made this winter in the introduction of steam-heating systems for cars. Nearly all the New York railroads will comply with the law, a few only having secured extensions of time from the Railroad Commission. The Boston & Albany, and several other New England railroads, are doing much in this direction, and attention has been called to it everywhere. The Chicago, Rock Island & Pacific has equipped its through trains between Omaha and Chicago, and other Western roads are also trying different systems.

The Railroad Commissions of Vermont and Minnesota have recommended legislation against car-stoves, and it is probable that some action will be taken in both States.

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THE *Railway Age* reports a total of 5,790 miles of new railroad completed in the ten months of the current year up to the end of October. Taking into consideration the work now in hand this indicates a total of over 7,000 miles for the year.

The greatest mileage reported for any one State is in California, where 485 miles of track were laid. Kansas and Georgia follow closely, both having added over 400 miles. Kentucky and Illinois each report between 300 and 400 miles, while five others—Texas, Alabama, South Carolina, Colorado, and Washington Territory—had each over 200 miles.

In one respect this year's new railroad building differs from that of 1887; it has been made up chiefly of short lines. The 5,790 miles reported by the *Age* were on 280 different lines, the average length of the roads or additions being thus only a little over 20 miles.

The building this year has been mainly what this fact would indicate—short branches, feeders, and local lines. Many of these are additions to existing systems, but there has been very much less construction of competing and interfering lines than last year, and no roads that can be called main or trunk lines are now in progress.

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WE are informed that applications for space for railroad machinery and appliances at the Paris Exposition of 1889 are not coming in rapidly to the United States Commission. Among those lately received are models of a rail-joint, a coupler, a turn-table, a train with ventilating apparatus, and a number of axles, steel-tired wheels, and street-car wheels.

Notwithstanding the fact that the great question in Paris just now is the new Metropolitan or city railroad, and the equipment which should be provided for it, no American locomotive builder has yet applied for space.

It is suggested to manufacturers that the Central and South American countries will be very largely represented at Paris, and that the Exposition will, therefore, offer a very good opportunity to reach the buyers of those countries at comparatively small cost.

Among the special features of the Exposition will be a "Retrospective Exposition of Industrial Work and Anthropological Sciences," which will virtually form a history of labor and the manifold applications of manual skill. The General Classification of this collection will comprise: 1. Anthropological and Ethnographical Sciences; 2. Liberal Arts; 3. Arts and Trades; 4. Means of Transportation; 5. Military Arts.

In each of these classes there will be displayed objects of all ages and all countries. Any resident of the United States who possesses objects that would add to the interest and value of this special exhibit can obtain all necessary information by applying to the Commission at its office, No. 1 Broadway, New York.

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THE situation in Austria, in relation to the supply of railroad ties, seems to be very similar to that in this country. The supply of timber at present is sufficient, and the prices are not high, but the consumption is growing, and the destruction of timber for this purpose considerably exceeds the average annual growth of the forests. The price of metallic ties is still too high in that country to permit of their general substitution for wood, and in order to prevent too great a destruction of the forests, considerable attention has been paid to the preservation of ties by various processes.

The article on this subject, as published in another column, gives some interesting statistics to the life of ties, including the experience of a number of years, and the facts presented there are of sufficient importance to merit care-

ful study. One to which especial attention deserves to be called is that with the preserving treatment certain kinds of timber are available for railroad use, which without it would be worthless for this purpose. This fact has been urged upon the railroad companies by Mr. Fernow, Chief of the Forestry Division of the Department of Agriculture, who deserves thanks for his efforts in this direction.

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SOME remarkable experiments have recently been made in England with armor-plates on a new plan, consisting of small plates of especially hard cast steel 3 in. thick fastened to a large plate of soft cast steel 7½ in. thick, the fastening being made by a special process.

The theory of this new plan is that should a shot strike one or more of the plates, the destruction would be confined to that particular small plate, and would prevent cracks from extending all over the plate. This was tested with projectiles of different kinds, and the theory was fully supported as far as the small plates were concerned. The method of holding them to the soft plate seemed to be imperfect, and several were detached in the test. The results, however, were sufficiently good to justify further experiments with this kind of composite armor-plate.

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THE Army Ordnance report for the last year does not show very much progress, although more is hoped for during the current year, when the new gun factory will be completed, and better facilities provided for manufacturing guns. The tests of the 8-in. guns having been continued with favorable results, extended tests have also been made of the 5-in. and 7-in. rifled guns. The 12-in. breech-loading rifled gun, hooped and tubed, has made some advance, one having been built and sent to the proving grounds, while another is nearly ready, and the tests will proceed as fast as proper powder can be procured. The tests of the Department have been delayed by a short supply of powder, but this trouble it is hoped will not be experienced in the future.

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THE present strength of our Navy and condition of the vessels is stated, in the annual report of Chief Naval Constructor Theodore D. Wilson, as follows: Five double-turreted monitors awaiting completion; two belted cruisers, preparing ways; 13 single-turreted monitors, in ordinary; 23 unarmored steel and iron vessels, four of which are in commission, 11 building, two repairing, five on station or undergoing repairs, and 11 iron and wood steam tugboats.

The payments made on account of vessels building under contract up to October 31 aggregate $3,266,195, and $885,349 was expended in the repair of ships, purchase of tools, etc. Five vessels were sold and condemned during the year.

The estimates for the current expenses of the year aggregate $936,452, while the appropriations were $868,952. In addition to these estimates $3,540,000 will be required to meet payments on account of hulls and outfits of new ships; but this sum has already been appropriated. The estimates include items of $50,000 each for the New York and Norfolk Navy Yards, to improve the plant. The Bureau recommends the immediate construction of experimental works, to cost $60,000, for use in the determination of the resistance and other qualities of ships by means of models.

The Mare Island Navy Yard is being fitted with a complete outfit of modern shipbuilding tools. The climate is such that it is perfectly practicable to conduct shipbuilding without the shelter of ship houses, which are expensive and do not favor rapidity of construction or excellence of workmanship on account of the darkness.

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IN Chief Naval Constructor Wilson's report it is stated that the old sloop-of-war *Hartford* is likely to be condemned, unless the act passed by the House of Representatives authorizing her repair becomes a law.

Enough cannot be said against such a proceeding, for her past record has endeared her to the American people, and she should be preserved as a monument of her past achievements. It has been suggested that if she has outlived her usefulness as a cruiser she should be preserved as a receiving ship.

There can be no doubt that preserving vessels, which have been distinguished in naval history, has a favorable effect on the Navy, and a ship like the *Hartford* or the *Constitution*, in our own Navy, or Nelson's *Victory*, in the English Navy, will always be of interest not merely as a relic, but also as a stimulus to patriotism and to the *esprit du corps* of the Navy.

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ADMIRAL PORTER, in his annual report to the Secretary of the Navy, while approving of the new class of steam vessels now being added to the Navy, still adheres to the belief that the best school for the education of seamen will be found in the old-fashioned sailing vessels, and he recommends that a few of this class be kept in service for the training of cadets and apprentices; steam vessels should be attached to the practice squadron, chiefly for exercise in gunnery. The Admiral says that the experience gained in the sailing vessels will be of service to officers on any sort of cruise or warship which has yet been devised, and that such experience can be gained in no other way.

The Admiral is an advocate of the Naval War College, and urges that the advantages derived from it are worth very much more than its cost to the Navy Department.

His opinion of torpedoes is apparently not very high; where they are planted in the bottom of a channel, he thinks that only a temporary stoppage would enable an attacking squadron to get rid of them. The movable torpedoes, such as the Whitehead and that class, have proved to be very uncertain in operation, and are not to be relied upon, while a properly equipped ship can defend itself from them with ease. The most formidable weapons of the kind are the dynamite or torpedo guns, firing shell loaded with high explosives, and he considers that this class of projectiles is capable of much greater development than it has heretofore received.

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MR. A. S. ABELL, proprietor of the Batimore *Sun*, has set an excellent example by presenting a library of well-chosen books to the new cruiser *Baltimore*, for the use of its officers and crew. The gift in this place is made as an acknowledgment of the naming of the vessel after the city. Mr. Abell's example should be followed by others, as a library is always a welcome gift to a man-of-war. The *Boston*, the *Atlanta*, and other new vessels are open to proposals.

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THE Russian Government is still considering the best methods of utilizing the Transcaspian Railroad as a commercial, as well as a military work. Preliminary exam-

inations have been made of the productive territory included in the Merv Oasis, and proposals for building a system of light railroads in that region are now under consideration.

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THE recent manœuvres of the German army included the movement of large bodies of troops by rail, and the special service organized for this purpose was fully tested in practical working. The results of the test are reported as very good, and in several cases an entire division was moved in a surprisingly short space of time. The Transportation Corps and the "railroad regiments" attached to the different army corps had a full opportunity of showing their efficiency. In this respect, as in almost all others, the German army organization is exceedingly thorough and practical, and under it a temporary railroad can be quickly built or an existing line can be taken hold of and worked with little or no delay, no time being wasted in preparation.

A German railroad regiment is, in fact, a fully equipped body of railroad employés under military organization, its ranks including men for every department of a railroad fully trained to respective duties and ready to begin their work at any moment they may be needed.

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IN a recent address before the British Institution, Sir C. W. Wilson refers to the effect which the Suez Canal has had on shipbuilding in that country. The immediate result was an increased activity, but the class of vessels built was inferior. The canal voyage to India requires a different ship from the Cape or ocean route, and those which have been built for that trade are not only smaller, but are lighter, less seaworthy, and not so strong as the older vessels which had to take the long ocean voyage, where storms were frequent and coaling stations few. The result is found in the fact that, with a great increase in tonnage, the proportion of ships which come up to the naval requirements and which would be available as cruisers in time of war has diminished.

This fact is not often so frankly stated as in the address referred to, but it has nevertheless been seen and appreciated by high authorities in England, who have not, however, been able to suggest anything which will change the tendency thus developed.

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## THE ENGLISH VERSUS THE AMERICAN SYSTEM OF RAILROAD CONSTRUCTION.

II.

AS a continuation of the article on this subject, published last month, the discussion of cars and other conveniences and facilities for traffic and travel by our two antipodal contemporaries will be reviewed in this article.

In discussing the merits of American cars, the *Jiji Shimpo* writer says that they are longer and wider than English cars, they have a passage-way through the whole train and a heating apparatus, while English cars have neither. He also says they oscillate less than English cars, and the latter are more dangerous in case of accident.

To this the *Mail* disputant replies, that the American passenger is obliged to squeeze past his neighbors, to their and his great inconvenience; that communication exists throughout American trains with the result that there is no peace nor quiet for an hour together, the center path being a highway for the numerous officials of the train, and for itinerant venders of books, fruit, candy, cigars, newspapers, and so forth, whereas in English cars "you escape the nuisance of perpetual ticket-punching, peddling, and nigger attendance;" that in an American car the passenger is compelled to sit upright in a chair, the back of which comes no higher than the shoulders, and gives no rest to the head, and it is not possible to stretch out one's legs or to recline, however empty the car may be, whereas in English cars you can rest your head against a high back; stretch your legs to their full extent, recline, as on a lounge, if the car be sufficiently unoccupied. American cars, he says, are well lighted and well warmed, but they are unbearably hot in winter, and owing to the terrible accidents caused by this system of heating laws had to be passed forbidding the use of stoves in cars. The windows, he continues, of English cars are about twice as large as those in American cars, and by reason of the method of the construction of the latter they do not present more than about half the areas of space for light and air afforded by the former internally, and in the hottest weather the traveler's head and face receive no breeze. The oscillation of American cars, he says, is so great that at 20 miles an hour one cannot safely walk without support, and that the weight per passenger of American cars is considerably greater than that of the British vehicle. Cars in England are now, he argues, largely lighted with gas, and in some instances with electricity.

Reading this discussion would probably have somewhat the same effect on a Japanese that many political disputes in this country have on the hearer—that is, he would conclude that neither candidate for favor is worthy of being selected. In such and other disputations there is, unfortunately, no known means of assigning a correct value to the facts and the reasons adduced on one side or the other. What is merely trivial may appear important, if presented in sonorous language, and with more or less personal accentuation. Thus it is true that American cars are longer and wider than English cars, and it is equally true that the seats in them are often crowded too close together, and that generally the seats in English cars are more roomy and more comfortable. But most English cars are without passage-ways through them, and therefore water-closets are impracticable, which would be an insurmountable objection to their use in this country, or in any other where there are long journeys. Now a passage-way should be not less than 22 in. wide, the seats, 38 in., the seat arms, 2 in., and the side of the car 6 in. thick, so that the total width would be 9 ft. 6 in. outside. To avoid frequent crossings from one car to another when passage-ways are used, their length must be increased, which makes the truck or bogie system essential. It is admitted that the good-natured American passenger is subjected to many annoyances from itinerant and local venders of sundry articles which generally he doesn't want, but the venders are merely incidental and not essential to the use of long cars and water-closets. It is also true that the backs of American car-seats generally "come no higher than the shoulders," and that they are often crowded too close together, but it would be very easy for our Japanese friends to get seats here with high backs, and to give more room between them. If "nigger attendance" is disagreeable banish the Ethiopian, and let the almond-eyed sons of the Orient attend their fellow-countrymen.

Heating apparatus is absolutely essential in cars for long journeys and in cold climates, and notwithstanding the

risk attending its use, as shown by some of the dreadful accidents which have occurred here, it is safe to say that many more people would die of sickness, consequent to exposure to cold, if no heating appliances were used for such journeys. The practicability of using steam heat on trains has also been shown, so that if heated cars are required the Japanese need have no fear of being roasted alive. It may be added that owing to the smaller number of steam-pipe couplings or stoves required on long than on short cars, there is less difficulty in heating the former than the latter.

With reference to the relative weight per passenger of English and American cars, there can be no doubt that the English cars have the least dead weight, but it is equally true that American cars are stronger than the others and will resist collisions unharmed, which would be totally destructive to the lighter vehicles. The additional dead weight is the price at which this strength and the convenience and comfort which results from communication through the train is bought. The cost of transporting dead weight has been greatly exaggerated, and it is quite certain under ordinary circumstances an increase of even as much as 50 per cent. of such weight adds very little to the expense of operating a road.

With reference to steadiness of motion it is largely a matter of the condition of the track. It must not be forgotten, though, that it is more important that a car should remain on the track than that it should ride steadily. Oscillation at high speeds and on an uneven or crooked road is, to a great extent, the result of an adaptation of the running gear to the inequalities of the road. In some cases if a car did not oscillate it would be liable to leave the track. It is, we think, unquestionably true that under all conditions of track that long cars with trucks or bogies run more smoothly and evenly than short cars without trucks, and on a rough road at considerable speeds there will be the difference that cars with trucks will remain on the track, whereas those without—if their wheel-bases are long enough to give steadiness—will not.

With reference to general comfort it must be admitted that no American cars have as yet been supplied with seats which are as comfortable as some of those in first-class English cars. For some reason American railroad managers have been slow to perceive that to make a seat comfortable abundant room is essential—room lengthwise, crosswise, and vertically. The Boston & Albany Railroad Company, for example, have spared no expense in building luxurious cars, and yet they crowd their passengers into seats which are spaced only 33½ in. from center to center. But every degree of roominess is now given in the seats of American cars. Reclining chairs of every variety can be had, adapted for any position of the passenger, except standing on his head, and he might even do that, if he is not comfortable without, so that if Japanese travelers yearn to "stretch their legs," American cars can be supplied which will give them unlimited opportunities for that exercise.

In the matter of classification of passengers, American practice offers a variety of systems to choose from. On many lines and trains there is but one common class, and one rate of fare. On other lines or trains there are parlor or drawing-room cars by day and sleeping-cars at night, and in some cases emigrant trains or cars for those who want to travel cheaply. "You pays your money and you takes your choice."

With reference to speed there, too, a wide choice is open. Some American trains run as fast as the fastest in England, although there are more fast ones there than here, but it is questionable whether very high speeds would be practicable or desirable on Japanese roads; but our American cars and locomotives are adapted for high speeds, as well as English rolling-stock is.

With reference to cost of construction there can be no doubt that the average cost per mile of American railroads is less than that of English roads, but that proves very little, excepting, perhaps, that those who built them here had less money to spend than the English brethren had. The truth is, the roads here have been built to meet the needs of the country. When there was a sparse population and little traffic the lines were pushed out with as little cost as possible. The road-way was cheap, and the rolling-stock and conveniences of travel were in accordance with and adapted to the needs of the section in which the lines were constructed. As population increased and the demands of the public became more exacting the roads and rolling-stock were improved, speed was increased, more luxurious stations were provided, heavier rails were laid, and more substantial bridges and other structures built.

Our foreign contemporary says of "social barriers" that, "if our friends and kinsmen beyond the water please to flatter their fancies by pretty dreams of universal brotherhood and sisterhood, let them have their foible." Whether "social barriers" are foibles or not, it is hardly worth while to discuss here. If the Japanese see proper to maintain them, American railroad practice will give abundant means to indulge the "foible." What is claimed for the American system of railroad building is that it is adapted to any condition of things likely to occur in a country like Japan. Under like conditions its cost is less than the system of construction which has been developed in England.

The *Mail* quotes some figures to show that the cost of operation of English roads is less than that of American lines. The basis of these data is the relative percentage which the working expenses bear to the receipts. It has been shown over and over again that such figures are delusive, as the rates received for the traffic are, in this country, constantly changing. If the rates are reduced the receipts are correspondingly diminished, but the expenses remain unchanged, so that the much-quoted percentage of expenses to receipts is really a function of the rates charged.

Regarding accidents, too, no comparison is possible, because no official or correct record is kept in this country, excepting in a few States, and the average length of the journeys traveled is not known correctly in either country. In any event, though, the frequency or infrequency of accidents is due more to good management in operating than to the adoption of either an American or European system of construction.

The question of whether the railroads of Japan shall be well or badly managed, does not depend upon the selection of either system. The perfection of their railroads, too, will depend largely upon the knowledge, ability, and integrity of those who have charge of them. Official corruption on railroads is a great evil in this country, but is not inherent in our system of construction. We believe the venerable practice of beheading criminal officials still exists in Japan. Let the Japanese

adopt, as part of their railroad system, an inexorable law that any railroad official who accepts a bribe in the performance of his duties shall be beheaded, and they will escape many evils which have attended the development of the railroad system here.

## THE SIBERIAN PACIFIC RAILROAD.

THE longest single line of railroad now seriously contemplated in the world is the Siberian Pacific Railroad, upon which the Russian engineers have been for some time engaged, and on which it is understood the Russian Government intends to begin work early in the coming year. This line is of interest, not only on account of its length, but from the fact that it will follow a route upon which there has been for many years a considerable commerce carried by somewhat primitive methods, and that it will aid in opening up and improving what is probably the greatest extent of undeveloped territory in the world, outside of the continent of Africa. Southern Siberia is, outside of Russia, almost an unknown country, but its productive capacity is undoubtedly great, and when made accessible and opened up to settlement—perhaps relieved from the incubus which always weighs a penal colony—it will appear as a new competitor on the markets of the world, and will yield sufficient traffic to support, not only one, but possibly several railroads.

The Siberian road, while purely a Government enterprise, differs from the Transcaspian line, from the fact that it will be built for commercial reasons chiefly, and not as a purely military road. The object of the Government is not only to open the country, but to furnish a convenient line for the Chinese trade, and to establish a connection with the Russian settlements and naval stations on the Pacific, which will probably play an important part in the future contest for naval and commercial supremacy, in which Russia undoubtedly expects to take a prominent part.

While the general plan of this Siberian road has been outlined, the location, except for a short distance at the western end, has hardly been begun, and for a greater part of its length nothing more than a slight preliminary reconnoissance can be said to have been made; nevertheless the country has been carefully studied for several years past, and it is understood that a very fair idea has been reached of the work which must actually be done.

The outlined plan of the road is for a line nearly 4,000 miles in length, extending from Tiumen, in western Siberia, the present terminus of the Oural Railroad, to Vladivostock, the chief Russian port on the Pacific coast. This line is divided into five principal sections, the first extending from Tiumen to Tomsk, the most important city in southern Siberia, a distance of 800 miles; the second section is from Tomsk to Irkoutsk, 1,050 miles; the third, from Irkoutsk to Oust-Strjelka, 800 miles; the fourth will follow the valley of the Amoor for 1,000 miles from Oust-Strjelka to Usuri, while the fifth section is a short one of 300 miles, leaving the Amoor at Usuri, and running nearly due south to Vladivostock.

These sections mark the chief geographical divisions of the line, but it is not proposed to build them all at once. In order to complete the line of communication as soon as possible, the intention is, it is said, to begin work at Tomsk, and to build the section from that place to Irkoutsk, as there already exists a navigable line from Tiumen to Tomsk by the Irtish and the Obi rivers. The construction of this section will be followed by that from Irkoutsk to Oust-Strjelka, both of these being through a region where a land route alone is available. The section of 1,000 miles from Oust-Strjelka to Usuri is covered by steamboat navigation on the Amoor and its tributaries, but Vladivostock lies away from the mouth of that river, and can only be connected with it by rail, so that the 300 miles necessary for that purpose will probably be almost the first part of the line to be built.

The three sections named include a total of somewhat over 2,100 miles, leaving about 1,850 miles which will have to be built later to complete the railroad line. It is said that the final rail terminus will not be at Vladivostock, which is not satisfactory as a port, and that the real intention is to carry the line further south, probably—if political considerations do not prevent—to a Corean port, one of the few good harbors on the Japanese Sea. This, however, is a matter of future consideration.

The greater part of the country through which this road will pass presents few or no engineering difficulties. For nearly 1,000 miles the route is over an almost level plain, where the only works of importance will be the river crossings, which will require some bridges of considerable size; but should haste, as well as economy in construction, be an object, most of these could be crossed, for a time at any rate, by steam ferries. The most important of these crossings will be those of the Tobol at Tobolsk, the Irtish at Omsk, the Obi east of Tomsk, the Tom at that city and the Yenisei at Krasnojarsk, all of which will require long and expensive bridges. It must also be remembered that in these rivers, and also in many of the smaller tributaries, the bridge substructures will have to be of very firm and solid construction in order to resist the great pressure of the ice in winter and spring.

The principal engineering difficulties will be found on the central section, where the road rises from the valley of the Irtish and crosses the Baikal Range, to reach Lake Baikal, which lies at a level of some 1,500 ft. above the sea, and must again descend from the lake and cross the Jablonoi Mountains which divide it from the valley of the upper Amoor. It is said, however, that passes have been found through the Jablonoi Mountains, through which the road can be carried at a level only slightly above that of the lake, and that one or more of these passes can be reached without the use of excessive grades, while the crossing of the hills to the westward of Lake Baikal can, by a slight detour, be made without encountering serious difficulties. Through the Amoor Valley the work will be easy, while from that river to the Pacific terminus the line can be run through a rolling country, presenting no great elevations or depressions. The winters, however, in the neighborhood of Lake Baikal are long and very severe, and more difficulty may possibly be encountered in operating the road than in constructing it. On the remainder of the line, while the winter climate is somewhat rigorous, it is stated that the snows are lighter and that less trouble may be expected than on many of the lines in Europe and Russia.

The consideration of this project has proceeded so far that already estimates have been made of the cost. The lowest, based upon the experience of the Government with the Transcaspian line, is that it will be from $25,000 to $30,000 per mile, while for a more permanent line, with allowance made for the solid construction required to

withstand the severe winters, the estimate is as high as $40,000 per mile. The actual cost will probably be somewhere between the two extremes; in all the estimates allowance has been made for the cost of hauling material over the long distances which will be required.

The full usefulness of the line will not be reached without several branches, and provision will be made for the building of these almost at the same time with the main line. Three or four will diverge to the northward and reach the more important of the Siberian cities, while one at least will be carried to the Chinese frontier—possibly across it—in the direction of Kiachta, which has for many years been the center of Russian trade with China. It is not improbable also that a branch from some point near the western end of the road may cross the Kara Mountains and join the Transcaspian road near Khojend, thus giving the Siberian line an outlet to the Caspian Sea, in addition to its connection with the Russian railroad system.

## NEW PUBLICATIONS.

PRACTICAL DESIGNING OF RETAINING WALLS: by PROFESSOR WILLIAM CAIN, A.M., C.E., SOUTH CAROLINA MILITARY ACADEMY. New York; D. Van Nostrand (price, 50 cents).

This excellent treatise of Professor Cain's, which was intended to be a revision of the original work of Arthur Jacob, but which was practically a new book, was issued some time ago as No. 3 of Van Nostrand's "Science Series." It has now been reissued, with the addition of an appendix giving a design for a very high masonry dam. This is of interest in view of the discussion which the Quaker Bridge Dam has caused, and, indeed, the design given and analyzed was prepared especially to meet the conditions presented by that dam.

THE STEAM BOILER CATECHISM: A PRACTICAL BOOK FOR STEAM ENGINEERS, FIREMEN, OWNERS, AND MAKERS OF BOILERS OF EVERY KIND: by ROBERT GRIMSHAW, M.E. New York; the Practical Publishing Company, No. 21 Park Row (price, $2).

This book is intended to be a practical treatise on the Steam Boiler, and a companion work to the *Steam Engine Catechism* and the *Pump Catechism* by the same Author. It is a compilation and collection of facts relating to boiler construction and management, presented with the intention of making them not only readily accessible, but clear and plain to any reader of ordinary education. The book is written in the form of question and answer—a form which, without doubt, presents many advantages in a work of this kind.

A minor objection to the book is its form. The small size of page was probably adopted with a view of making a book which could be carried in the pocket; but where the size runs up to over 400 pages, as in this case, it grows uncomfortably thick. Moreover, the small page limits the size of engravings, so that many must either be put in as folding leaves or insets—always a bad thing in a book—or else made on a smaller scale than they should be to be clear and agreeable to the eye.

These are minor objections, however, and the Boiler Catechism ought to fill a considerable field. There is room for it, for there has been till recently no practical book on boilers which is readily obtainable or within the means of many men to whom it would be useful. It is a book for learners rather than for experts, aiming to present to them the results of experience and approved practice.

One thing, which is too often lacking in books of this kind, a sufficient Index, is given in this work, and there is little fault to be found with its general plan and arrangement.

TWENTY YEARS WITH THE INDICATOR, BEING A PRACTICAL TEXT-BOOK FOR THE ENGINEER OR THE STUDENT, WITH NO COMPLEX FORMULÆ: NEWLY ARRANGED AND COMPLETED IN ONE VOLUME: BY THOMAS PRAY, JR., M.E. New York; John Wiley & Sons, 15 Astor Place, and London; E. & F. N. Spon.

This book is intended to present the results of many years' observation and experience with the indicator, in the form of a practical handbook, or text-book, for the working engineer, the steam user, or the student. It gives a description of the indicator and the method of applying it, illustrated by many cases drawn from practice, and goes on to show the use to which it may be put and the lessons to be drawn from its showing.

The applications made include many forms of stationary engines, and also marine engines of a variety of types. The object has been, as the Author says, not to criticise or to favor any special kind of engine, but to give the conclusions drawn from a wide experience, to record facts, and to show how further facts can be ascertained, and the lessons drawn from them and applied to the best advantage.

The use of the indicator has been very much extended in the past few years, and with excellent results. Occasionally, in incompetent hands, some harm may have been done by conclusions hastily or incorrectly drawn, but in the main the employment of this instrument has added to our knowledge, and has been the cause of many improvements in engine practice. Mr. Pray's book is a very convenient and useful manual, and will repay study by those for whom it is intended.

POOR'S DIRECTORY OF RAILROAD OFFICIALS: THIRD ANNUAL NUMBER, 1888. New York; Poor's Railroad Manual, 70 Wall Street.

This is the annual supplement to *Poor's Manual*, containing the names and addresses of railroad officers, which for three years past have been given in a volume separate from the *Manual*. It contains, in the first place, an alphabetical list of railroad companies, giving the directors and officers of each company. This is supplemented by an alphabetical index of names, containing the names of all the officers given in the book, with references to the pages on which they may be found under their proper headings. In addition to the steam railroads there is also given a list of logging, and other private railroads, with names of their owners. This is a very convenient addition for many purposes, although it must be necessarily a difficult one to make complete. How complete it is in this volume, we have no means of judging. There is also a list of the street railroads of the United States, giving their location and officers and separate lists, which are intended to save time to those using the book, giving in one the General Managers or General Superintendents of the principal railroads, in another the Chief Engineers, in a third the General Freight and Passenger Agents, in a fourth the Master Mechanics, in a fifth the Master Car-Builders, in a sixth the

Master Car-Painters, and lastly, in a seventh the Purchasing Agents. There are also lists of Bridge-Builders, of Car-Builders, Car-Wheel, Spring, and Axle Manufacturers, Locomotive-Builders and of Rail Mills, and Railroad Contractors. A list of railroad associations is also given, and the names of the Railroad Commissioners of the several States complete the information presented, with the exception of some pages occupied by a directory of the Mexican, Central American, and South American railroads, and a few pages on the railroads of Great Britain and Ireland.

The information given seems to have been carefully collected and prepared, although a slight examination has shown some mistakes in the list of manufacturers, especially the car and locomotive builders. The book, however, is a very useful one, and almost indispensable to any one engaged in railroad or kindred business. There is one advantage in having the *Directory* in a separate volume from the *Manual*, and that is that the *Manual* itself is now necessarily so large a book as to be somewhat cumbrous for constant use, while the *Directory* is a much smaller and more convenient volume.

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CHINA. TRAVELS AND INVESTIGATIONS IN THE MIDDLE KINGDOM: A STUDY OF ITS CIVILIZATION AND ITS POSSIBILITIES, WITH A GLANCE AT JAPAN. BY JAMES HARRISON WILSON, LATE MAJOR-GENERAL, U. S. VOLS., AND BREVET MAJOR-GENERAL, U.S.A. New York; D. Appleton & Company.

General Wilson made an extended visit in China, going there in the fall of 1885, and remaining there for nearly a year, his object being to see to what extent the country was available at the present time as a field for investment of foreign capital. Whether the people were ready for railroads; whether, if built, they would pay; and, further, whether the construction and management could be secured for Americans upon such terms as would return a fair interest on the capital invested, with due regard to the risks involved. Carrying with him introductions to men high in official position he was enabled to see much more of the real industrial and economic condition of the country than most travelers are enabled to do, and he spent his time in making a careful study of the country and people. The results of his observations are given in the present volume, which contains an account of his travels and of his interviews with Chinese officials, with some carefully-made studies from such statistics as he was enabled to procure from the closely-guarded Chinese official records. He has also some interesting remarks on the nature of the Chinese Government, and the results of some past movements in that country, including the Tai-Ping Rebellion, the origin and course of which have always been somewhat of a mystery to foreigners.

His conclusions were in some respects favorable, in others not; he is inclined to believe that the people and country are ripe for railroads, and that there is an excellent opportunity for introducing Western industrial methods in the opening of mines, the working of metals, etc., but he is not inclined to believe that this work will be done, to any great extent, by foreign capital, or by foreign labor. "It will be done," he says, "whenever they can be shown that these can be done with their own money and by their own labor, under the direction of foreign experts, who will treat them fairly and honestly." The only probable market which he foresees for foreigners is in the supply of material and equipment for the first railroad lines to be built.

General Wilson has given us in this volume, not only an entertaining record of travel but also a better and more compact view of the present political and industrial situation of China than any probably which has yet been published, for, although he does not profess to have made or attempted an elaborate work, he has nevertheless given in a brief and readable form much that is valuable and interesting to students of the present condition and probable future prospects of the "Middle Kingdom."

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## ABOUT BOOKS AND PERIODICALS.

THE POPULAR SCIENCE MONTHLY for November has an article on the Problem of a Flying Machine, by Professor Joseph W. Le Conte, in which the question of aerial transportation is discussed. Altruism Economically Considered, by Charles W. Smiley, is an article which will repay reading by all who are interested in social questions.

Mr. McKennan's remarkable series of articles on Siberia in the CENTURY MAGAZINE, while devoted chiefly to the consideration of the exile question, have much that is of interest on the resources and nature of that vast country, which has heretofore been almost unknown.

A novel "Time Table with Notes" is issued by the Chicago, Burlington & Quincy Railroad. It contains a description of "The Burlington's Number One Train," as surpassing all others in speed, leaving Chicago daily at noon and reaching Denver at nine o'clock the next evening; an account of the important stations along the route; also a map showing the through lines of the Burlington route.

This Time Table will be a great saving to conductors, as it answers many of the questions which they have been compelled to answer heretofore, and gives travelers the information which they would naturally ask for.

A neat and very attractive advertisement, in the form of a miniature copy of SCRIBNER'S MAGAZINE, is issued. It contains several reduced illustrations, Twenty Questions About Railroads, Railroad Signals, as in use on a majority of American Railroads, and Rules for Train Management; it also gives a few of the features offered to the readers of the Magazine during 1889, including articles on Railroad Management, by General E. P. Alexander; the Railroad Postal Service, by ex-Postmaster-General Thomas L. James; Railroad Accidents, etc.

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## BOOKS RECEIVED.

FACTS ABOUT IRELAND: A CURVE-HISTORY OF RECENT YEARS: BY ALEXANDER B. MCDOWELL, M.A. London; published by Edward Stanford.

OCCASIONAL PAPERS OF THE INSTITUTION OF CIVIL ENGINEERS. London, England; issued by the Institution. The present installment of these papers includes the River Clyde, by Daniel Macalister; a New Method of Investigation Applied to the Action of Steam-Engine Governors, by Professor V. Dwelshauvers-Dery; Alpine Engineering, by Leveson Francis Vernon-Harcourt.

SIXTEENTH ANNUAL REPORT OF THE COMMISSIONER OF RAILROADS OF THE STATE OF MICHIGAN FOR THE YEAR 1888: JOHN T. RICH, COMMISSIONER. Lansing, Mich.; State Printers.

THE GOULDS MANUFACTURING COMPANY CATALOGUE OF PUMPS AND HYDRAULIC MACHINERY: TWENTY-SEVENTH EDITION, 1888–89. Issued by the Goulds Manufacturing Company, Seneca Falls, N. Y., and 60 Barclay Street, New York. This is an exceedingly neat and complete catalogue of the kind, including pumps and pumping machinery of almost every description.

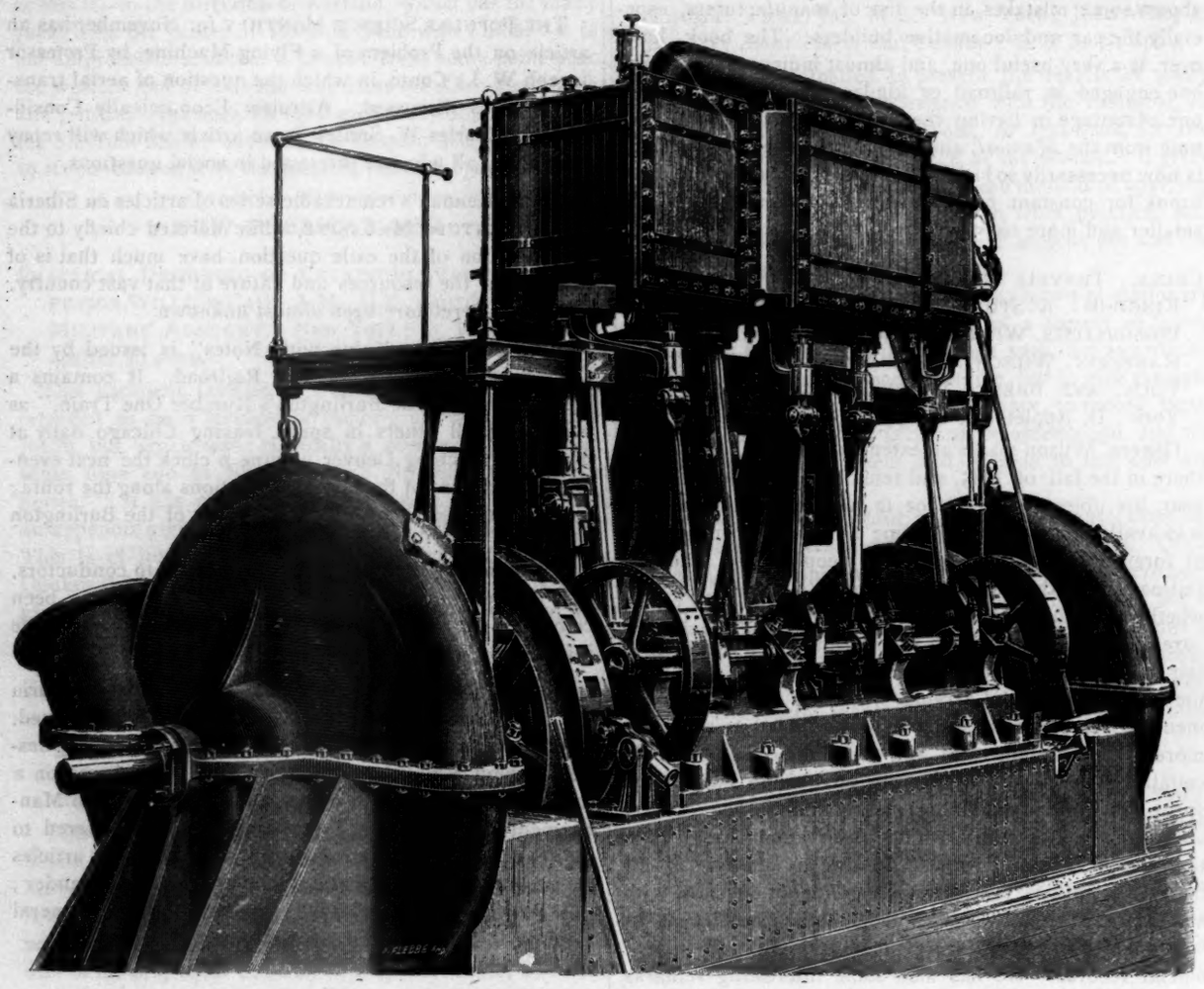
WELDING, TEMPERING, BRAZING, FORGING, AND SHAPING OF METALS BY ELECTRICITY. Boston, Mass.; issued by the Thomson Electric Welding Company.

HARRINGTON'S SCREW-HOISTING MACHINES, HAND-POWER ELEVATORS, AND OVERHEAD TRAMWAY SYSTEM: CATALOGUE. Philadelphia; Edwin Harrington, Son & Company.

## TRIPLE-EXPANSION PUMPING ENGINES FOR AUSTRALIA.

(From the London *Engineer*.)

THE accompanying engravings show a fine set of pumping machinery of the triple-expansion type—the first, we believe, which has been applied to centrifugal pumping—constructed by the firm of W. H. Allen & Company, of York Street Works, Lambeth. These pumps will be shortly erected at Mildura, Australia, where a complete irrigation scheme will commence. The pumps themselves are of the centrifugal form, and are capable of discharging 23,000,000 gallons per day to a height of 35 ft. at 200 revolutions per minute. The engines are generally of the marine type, and are fitted with cylinders 13 in., 22¼ in., and 34 in. diameter by 18 in. stroke, running at 200 revolutions per minute, giving a piston speed of 600 ft. per minute. The pressure of steam is 140 lbs. at the cylinders. The engines are connected direct to the centrifugal pumps,



TRIPLE-EXPANSION ENGINES WITH CENTRIFUGAL PUMPS.

BUILT BY W. H. ALLEN & COMPANY, LAMBETH, ENGLAND.

and, as will be seen, are mounted upon a strong wrought-iron bed-plate, to which are attached the two pumps. The engines have been made with all the latest improvements, and are supplied with a separate combined direct-acting air-pump of unusually large dimensions, on account of the high temperature of the condensing water, which averages as much as 80 degrees; the air-pump is mounted upon a massive cast-iron bed-plate having the engine attached thereto. This engine will have to travel about the same speed as the main engines to maintain the desired vacuum. The engines are finished bright, and very similar to the usual high-class work in waterworks engines. For low-lift pumping of any kind, whether for drainage or irrigation, this particular combination offers great possible advantage, by reason of its economical working.

## THE PRINCIPLES OF RAILROAD LOCATION.

By Professor C. D. Jameson.

(Copyright, 1887, by M. N. Forney.)

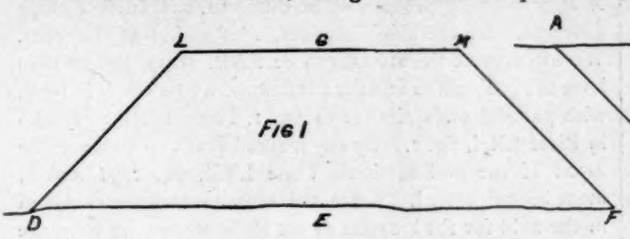
(*Continued from page* 491.)

### CHAPTER XXXVIII.

### LAYING OUT CUTS AND FILLS.

The method that is used is more easily executed than explained. In the level cuts or fills, the side heights or elevation of the slope stakes are the same as the center stake, and the side distances are obtained as we have explained. In the example now before us this is not the case, however.

On one side the slope stake is higher than the center stake, and on the other lower. Still, taking the fill at the slope stakes



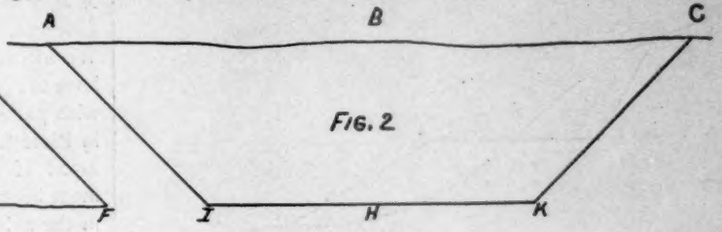
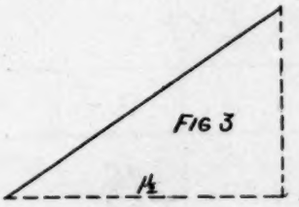
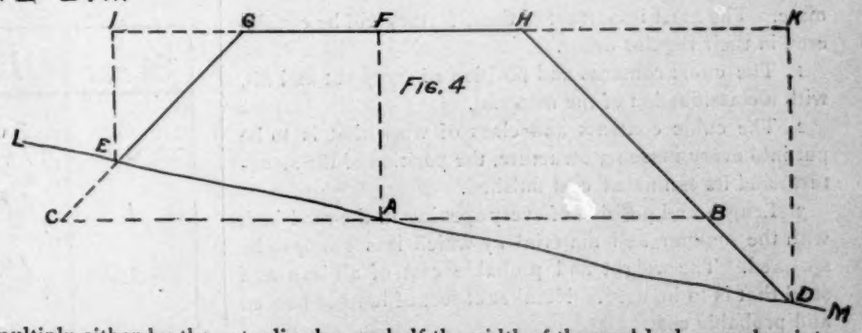




PLATE LVIII




—that is, $I\,E$ or $K\,D$, Plate LVIII—multiply either by the ratio of slope, and add to the product one-half the width of the road-bed, and the result will be equal to $I\,G$ or $H\,K$. The work is best done with a Wye level, and the points $E$ and $D$ found by trial. Assume some point on the ground at as nearly a right angle with the center line at the center stake used as can be judged by the eye. Measure its horizontal distance from the center stake. Have the level-rod held on it, and find the difference between its elevation and the elevation of the grade at the center stake used. Multiply this difference in elevation (or, in other words, the side cut or fill) by the ratio of side slope. Add one-half the width of the road-bed to the product, and if the result equals the distance of the assumed point from the center stake, the assumed point is the correct position for the slope stake. In case the side distance and the above result do not coincide, then move the rod to another trial point. The rapidity with which these stakes can be put in depends solely upon the skill and ability of the leveler.

But with practice one or two trials only are necessary in the majority of cases.

At the same time the slope stakes are being put in there should also be put in stakes at those points where the grade line cuts the surface of the ground—that is, where the character of the work changes from a cut to a fill, or *vice versa*.

Thus, in Plate LIX, let $A\,B\,C$ represent the surface of the ground on the center line, and $D\,E$ the grade line, 1, 2, 3, 4, 5, 6, etc., representing the stations. At the point $L$ the work passes from a cut $A$ to a fill $B$, and at $M$ from a fill $B$ to a cut $C$. These points, $M$ and $L$, should be found on the ground by means of trial with the level and stakes marked "grade" put in at them. When there is only one grade stake put in at each point it should be on the center line. Where the ground is very irregular it is sometimes advisable to put in not only the center grade stake, but also one on each side of it, and distant from the center line by one-half the width of the road-bed, as such points as where the each edge of the road-bed cut the surface.

The distances to all these stakes should be carefully taken in reference to some center stake and recorded, so that they can at any time be replaced if lost.

In side-hill work—that is, where the work on one side of the center line is in cut and the other in fill, as shown in

PLATE LIX

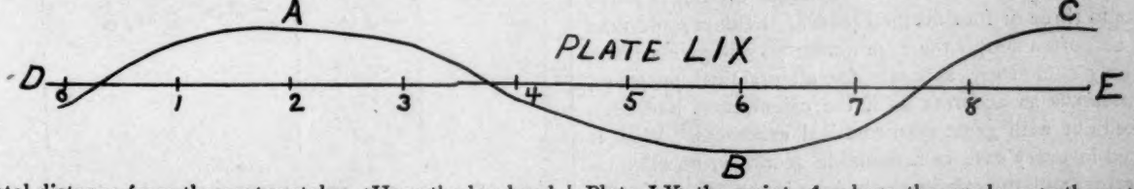



Plate LX, the point $A$, where the grade cuts the natural slope, should be marked by a stake, and its distance from the center stake measured and recorded in the cross-section book.

When the slope stakes are put in we have the following record of the work, as shown in Plate LXI:

1. The number of the stations and the plus stations, where for any reason a stake has been put in, such as a grade stake.

Down the center of the page, column 3, the center heights, or the cuts and fills on the center line, with the appropriate sign; on each side of this, columns 2 and 4, we

have the side distances written above the line, as the numerator, and the side heights written below the line, as the denominator, with its appropriate sign.

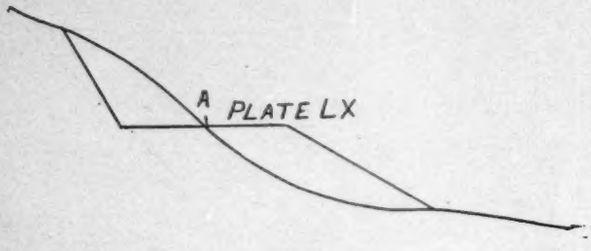
From these notes any of the stakes can be replaced at any time if lost.

From these cross-section notes that are taken in the field can be calculated at once the cubical amount of material that must be moved in the construction of the railroad.

## CHAPTER XXXIX.

### ESTIMATING COST OF CONSTRUCTION.

In estimating the probable cost of construction, it is necessary to know the total amount of material (usually in cubic yards or meters) that must be moved, and also approximately the classification of this material—that is, what amount will be solid rock, what hard-pan, and what earth. There are innumerable other factors, the probable cost of which must be included in any preliminary esti-




mate. The most important of these factors will be considered in their regular order.

1. The cubic contents and position of every cut and fill, with a classification of the material.

2. The cubic contents and class of work that is to be put into every masonry structure, the position of the structure, and its estimated cost finished.

3. Length and position of every opening in the road-bed, with the manner and material by which it is going to be spanned. The weight and probable cost of all iron and steel that is to be used. Number of feet of lumber needed and probable cost.

These are the most important factors that have to be considered in a PRELIMINARY ESTIMATE, and when we are to estimate the cost in actual dollars and cents, the question of the supply and cost of labor becomes a very important item.

In making a preliminary estimate, it must always be remembered that the results to be obtained are not required to run to three or four decimal places. Seldom more than one, and often simply the even quantities will give a result not only sufficiently accurate for all practical purposes, but *actually* as accurate as if the calculations had been worked out with great mathematical exactness. What is desired in every case is reasonable accuracy, no cumulative error, and the whole work done in the least possible time.

In all preliminary work saving of time is the great object, whether it is preliminary work in the field or preliminary estimates in the office. We will take up first the calculation of earthwork. This includes rock, hard-pan, and earth. It is absolutely impossible to calculate the number of cubic yards of material in any one station with greater accuracy than one decimal place, unless an amount of field work was done that would be all out of proportion with the results obtained. This is due to the natural irregularities of the ground between the stations. In any practical method, the sides of the prism between any two stations are supposed to be plane surfaces, which they are not, as can be easily seen; and suppose even that with an extreme refinement of calculation they are treated by means of calculus as warped surfaces, even then many of the irregularities of the ground would not be taken into account, and the final result would be actually no nearer the exact amount of material than if some of the more simple methods were used.

In Plate LXII, fig. 1, let $F\,G\,H\,D$ represent the section of a cut at right angles to the center line of the road. This is a similar section to what we would have at every station of the road in cut, and the reverse with a narrower road-bed is what we would have in fill.

We will suppose that the station next to the one shown in Plate LXII, fig. 1, is still in cut, and therefore in general outline is similar to it, although the center height, $A\,B$, will in all probability be different, the surface slope different, and the side distances, $F\,A$ and $A\,D$, different. We will assume the stations to be 100 ft. apart, and we then have the problem to find the contents of a prism 100 ft. long, with parallel ends similar to fig. 1, Plate LXII, as shown in Plate LXII, fig. 2. By any method that can be used, the areas of the end sections, Plate LXII, fig. 2, $A$ and $B$, must be calculated. From the cross-section notes taken in the field for the location of the slope stakes, we have the

PLATE LXI

| Sta. | L. | C.H. | R. |
|---|---|---|---|
| 0 | $+\frac{34}{14}$ | +20 | $+\frac{49}{26}$ |
| 1 | $+\frac{22}{8}$ | +10 | $+\frac{31}{14}$ |
| 2 | $+\frac{10}{0}$ | +4 | $+\frac{22}{8}$ |
| +30 | 00 | 0 | 00 |
| 3 | $-\frac{29}{14}$ | −6 | $-\frac{8}{0}$ |
| 4 | $-\frac{56}{32}$ | −20 | $-\frac{23}{10}$ |
| 5 | $-\frac{44}{30}$ | −30 | $-\frac{32}{16}$ |

center height, $A\,B$, Plate LXII, fig. 1, the side distances, $A\,F$ and $A\,D$, and the side heights, $F\,E$ and $D\,C$. We also know the width of the road-bed, $W$, and the ratio of slope, $N$, which are constant for any one cut or fill. The area of this polygon, $F\,D\,H\,G$, may be found by either of the following formulas:

$$A = \frac{C\,D}{2} + \frac{S\,W}{4}. \qquad (1)$$

$A$ = area;
$C$ = center height, $A\,B$;
$D$ = sum of side distances, $A\,F + A\,D$;
$S$ = sum of the side heights, $F\,E + D\,C$;

$W$ = width of road-bed, $G\,H$, or

$$A = \left(\frac{C}{2} + \frac{W}{4\,N}\right) D - \frac{W^2}{4\,N}. \qquad (2)$$

$N$ = ratio of slope, and the other letters represent the same as in the first formula. The formulas 1 and 2 will give the area of any "three-level" sections. By a "three-level" section is meant one where the center height and the two side heights are given. In contradistinction to those where only the width of road-bed, angle of slope, and center height are given, or those where, owing to irregularities in the surface or the large size of the work, five or more elevations are taken in the cross-sectioning. After having obtained the end areas and as many intermediate areas as may be deemed necessary, the next thing is to find the solid contents of the prisms of which these are sections. The length of these prisms in ordinary American railroad practice is 100 ft., and among the innumerable methods used in finding the cubic contents, the two following ones are all that will be explained here, owing to the facility with which they can be used, and also owing to the fact that the results obtained are as accurate as any of the more complicated methods on account of the inaccuracy, unavoidable in the data we have to start with. The method most in use is what is known as "average end areas."

$$M = \frac{A + B}{2}\,l\,;$$

$M$ = cubic contents;
$A$ and $B$ the areas of the end sections;
$l$ = length of the prism.

As we have said, the length of the prism is usually 100 ft. Now, if instead of dividing the sum of the end areas by two for the average end area, and multiplying the result by 100, the length of the prism, we multiply each end area respectively by one-half the length of the prism and add the results, the total will be the same.

We must divide this result by 27, the number of cubic feet in a cubic yard.

Therefore, multiplying equations 1 and 2 by $\frac{50}{27}$, we have

$$M = \frac{50}{54}\,C\,D + \frac{25}{54}\,S\,W \qquad (3)$$

$$M = \frac{50}{54}\left(C + \frac{W}{2\,N}\right) D - \frac{25\,W^2}{54\,N}, \qquad (4)$$

either of which equations will give the number of cubic yards in a required prism 50 ft. long. How nearly correct this result is depends upon the difference between the two end areas. If these end areas are equal, the result obtained by equations 3 or 4 will be correct, but otherwise it will always be in excess. The correction to be applied for this excess we will take up later.

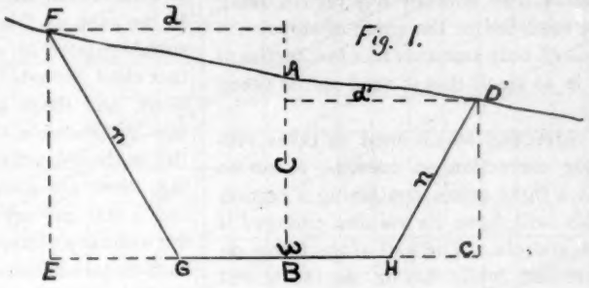



Fig. 1.

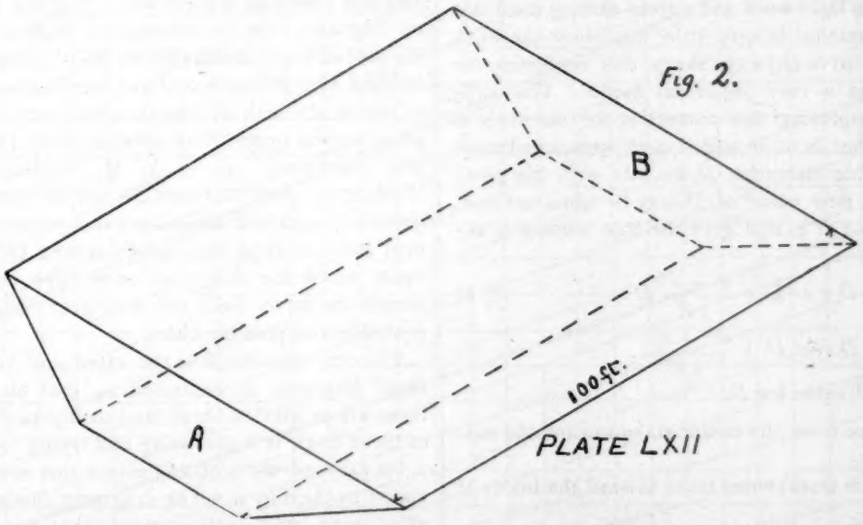



Fig. 2.

PLATE LXII

Another method that is always given in all text-books on the subject as the most accurate, and one that is very seldom used in the field is the Prismoidal Formula.

$$M = \left(A + 4\,C + B\right)\frac{l}{6}. \qquad (5)$$

$M$ = cubic contents;
$A$ = one end area;
$C$ = area midway between $A$ and $B$;
$B$ = the other end area;
$l$ = length of prism.

This formula undoubtedly gives the contents of the prism under all circumstances with much more accuracy than either 3 or 4. But it has this disadvantage: the dimensions of the area $C$ must either be taken in the field, which doubles the amount of field work, or else approximated in the office by taking one-half the sum of the corresponding dimensions of the end sections for the dimensions of the middle section $C$. This greatly increases the office work,

But as the difference in the results given by the method of Average End Areas and the Prismoidal Formula depends upon the *difference* between the end areas and not upon the actual cubic contents of the prism, the following formula will give the correction, which should be subtracted from the result obtained from the end-area formula.

$$P = \frac{C - C'}{3.24}\left(D - D'\right). \qquad (6)$$

$P$ = prismoidal correction.

$C$ and $C'$ = respective center heights of the end sections.

$D$ and $D'$ = respective sum of the side distances of the end areas.

This formula (6) gives the correction in cubic yards for the entire station 100 ft. long, and is to be subtracted from the total cubic contents of the station.

This formula (6) holds true without any regard being had to the width of the road-bed or the angle of slope.

When $C - C'$ or $D - D'$ only amounts to a few tenths of a foot, the correction is so small that it need not be taken into account.

There is one other correction which must be taken into account, and that is the correction on curves. It can be very readily seen that a right prism containing a certain number of cubic yards will have its volume changed if bent around the arc of a circle. The half of the prism on the outside will be increased, while that on the inside will be decreased. On light work and curves of long radii this difference would amount to very little, but where the work is heavy and the curve anyways sharp, this correction for curvature becomes a very important factor. The most simple form of employing this correction for curves is to find the amount that is to be added to or subtracted from the sum of the side distances, $D$, so that with the given radius of curve a new value of $D$ may be obtained that, used in equations 3 or 4, will give the true volume of the prism.

$$D\,c = D + \frac{d - d'}{3\,R}\,D \qquad (7) \text{ or}$$

$$D\,c = D + \frac{d^2 - d'^2}{3\,R}. \qquad (8)$$

$D\,c$ = corrected value for $D$.

$d$ = side distance from the center stake toward the outside of curve.

$d'$ = side distance from center stake toward the inside of the curve.

$R$ = radius of the curve, or using $d$ and $d'$ without any regard to the direction of the curve, the correction is to be added when the side distance is the greater on the convex side of the curve, and subtracted when greater on the concave side.

When running to or from a tangent point only one-half the correction should be applied.

The diagram, Plate LXV, is calculated for curves of 10°, and substituting this radius for $3\,R$ in equation 7, we have

$$D\,c = D \pm \frac{d - d'}{1719}\,D.$$

The last part of the equation being the correction that is taken from the diagram, and which must be added to or subtracted from $D$ as the highest ground, is on the outside or inside of the curve.

This correction in the value of $D$ should be made before any estimate of quantities has been made and the corrected value used in equations 3 or 4. We now have all the equations necessary for the calculation of the amount of material that must be moved in the construction of the sub-grade of a railroad. Should the occasion arise when it is necessary to calculate the volume of any irregular-shaped masses of material, the whole mass should be divided into triangular prisms, the end areas found, and the average end areas multiplied by the length of the prism.

## CHAPTER XL.

### DIAGRAMS AND TABLES IN ESTIMATING WORK.

If in calculating the volume of material in each station on the line equations 3 or 4 had to be solved, with the ever-changing values of its various terms, the process would be one occupying much time, and, considering the excessive amount of time necessary, of very little practical value. In the case of "level cuttings or fills" it is an extremely simple matter to calculate once for all a series of tables that shall include within their limits all probable dimensions, and there are many of these tables in existence. See Trautwine's "Engineers' Pocket Book," pp. 732–41. But in three-level sections, such as we have been considering, there are so many variable terms in the equations 3 and 4 that any set of tables of such an extent as to cover the ordinary dimensions of ordinary practice would be of such tremendous size as to be utterly of no use or value. But this objection is overcome. A series, not of tables, but of diagrams, can be constructed, from which with any of the probable dimensions the values of equations 3 and 4 can be read with greater speed and facility than from any series of tables, and with all necessary accuracy. The most complete treatise upon "Computation from Diagrams of Railway Earthwork" is by A. M. Wellington, C.E. Mr. Wellington gives a complete set of plates, covering all probable cases and dimensions that occur in railroad practice, and a book of explanation setting forth the principles upon which the diagrams have been constructed, with directions as to their use and great adaptability to all probable and possible cases.

The only drawback to the rapid and continuous use of these diagrams as published is, that all the lines upon them are printed in black, and owing to the great number of these lines, it is confusing and trying to the eyes.

On railroad work of any extent this can be entirely obviated by having a set of diagrams made in the drafting office upon cross-section paper, that engraved in green, with one inch divided into tenths, being the most suitable. The main lines can then be put in black and the subdivisions in red.

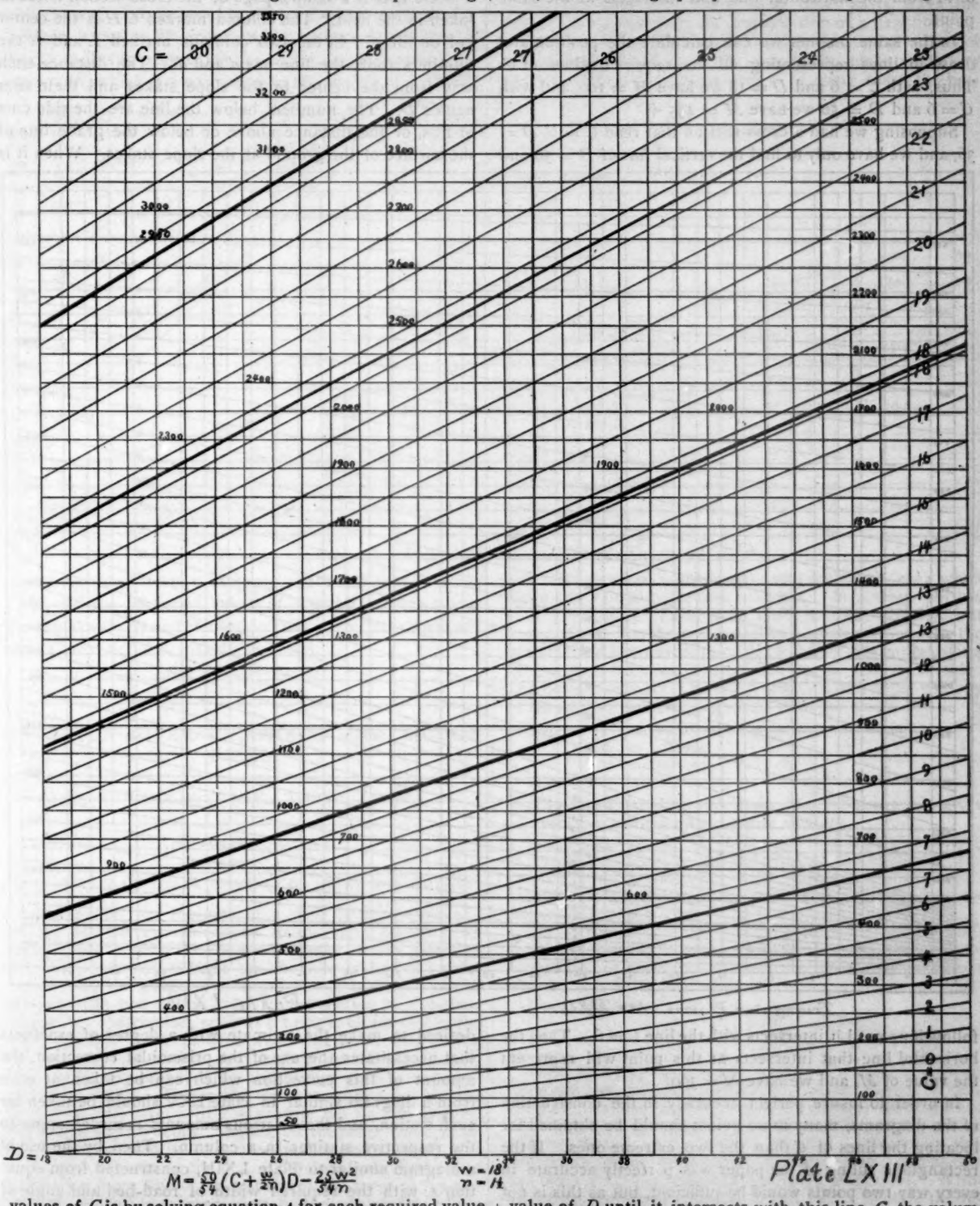
As upon any one railroad the width of road-bed and angle of slope would be uniform for all fills, only one diagram would be needed for this, and for cuts, one for each different slope that would be used. Three would probably be sufficient. Then with one containing the prismoidal correction and correction for curvature, the set would be complete—five in all.

Plate LXIII shows a reduced copy of a diagram for a road-bed of 18 ft. and the slopes one and one-half to one. On this copy the center heights are only taken at every even foot, as, owing to its reduced size, it is given simply as an example, and not for use.

The manner of construction is as follows: Take equation 4. The width of the road-bed ($W$) and ratio of slopes ($N$) are constants. We have for variables the distance be-

tween the slope stakes $D$, the center height $C$, and the volume $M$. The values of $M$ are laid off upon the vertical lines and represented by the horizontal lines. The values of $D$ are laid off upon the horizontal lines and represented by the vertical lines.

The different values for $C$ are represented by the inclined lines. The manner of obtaining the lines representing values of $C$ is by solving equation 4 for each required value of $C$, with the values of $D$ taken at the probable minimum and maximum. In this way we obtain two values of $M$ for two corresponding values of $D$. Follow up the vertical line representing the minimum value of $D$ until it intersects with the horizontal line representing the value $M$ as obtained by equation 4. At the intersection of these two lines make a point. Follow up the vertical line representing the maximum value of $D$ until it intersects with the corresponding value of $M$, and make a point. A straight line connecting these points will represent the one value of $C$, and following up any vertical line representing some value of $D$ until it intersects with this line $C$, the volume or value of $M$ for these values of $C$ and $D$ will be represented by the horizontal line that intersects $C$ at the same point that it is intersected by the given value of $D$.




Referring to Plate LXII, fig. 2, solving equation (4) with

$C = o$, $D = 18$, we have $M = o$; then with $C = o$, $D = 50$ we have $M = 177+$

Connecting point $A$ on the left, $M = o$, with $B$ on the right, $M = 177+$, we get the line $A\,B$, representing $C = o$, and by following up any of the vertical lines until they intersect with the line $A\,B$, we can then read off at once the value of $M$ from the horizontal line that intersects at the same point.

In the same manner we can calculate the position and draw in lines representing all the required values of $C$. Thus, with $C = 6$ and $D = 18$ we have $M = 100$, and with $C = 6$ and $D = 50$ we have $M = 455+$

Supposing we had a cross-section that read $C = 6$, $D = 36$, and we have only to find the vertical line of $D = 36$ and follow it up until it intersects with the line $C = 6$. Then the horizontal line that intersects at this point will represent the value of $M$, and we have $M = 300$.

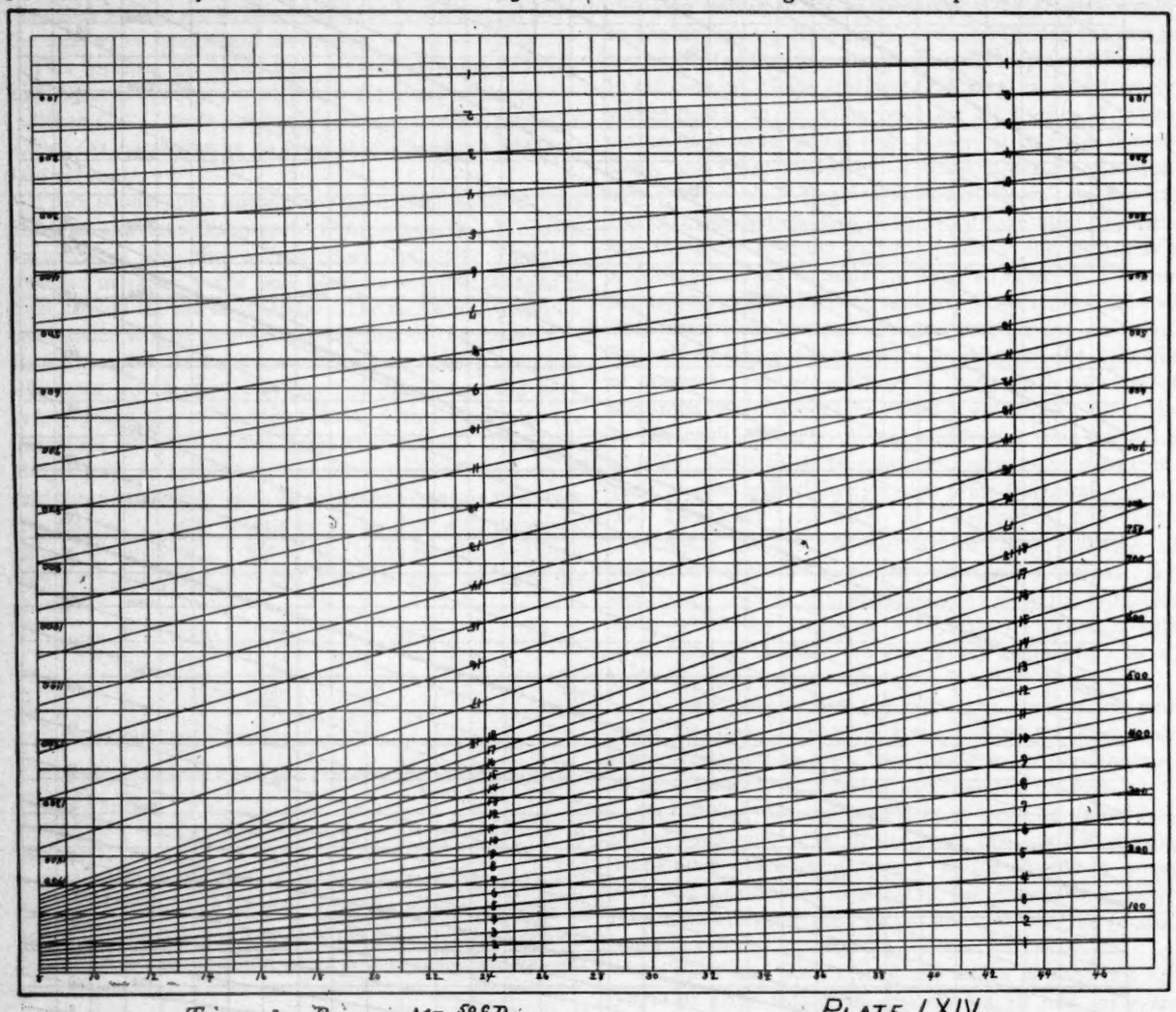
In order to insure perfect accuracy in the construction of the diagrams, many more points should be obtained for locating the lines of $C$ than the two extreme ones. If the rectangular ruling of the paper was p rfectly accurate in every way two points would be sufficient, but as this is not the case, it is a good plan to calculate about every fifth point and then connect them. Upon these diagrams can be put the curved line giving the values of $M$ for level sections.

Plate LXIV is a reduced copy of a diagram of triangular prisms, and Plate LXV a diagram containing the prismoidal correction and the correction for curvature.

These diagrams are given merely as an illustration of what the diagrams are, and are not supposed to be either of sufficient size or detail for actual use.

The manner of using the diagrams is as follows:

Plate LXI is a sample page of the cross-section notes as taken in the field. The column marked $C\,H$ is the center cut or fill $C$. In the two columns marked $L$ and $R$ the numbers above the line are $d$ and $d'$. The distance each way from the center to the slope stakes and their sum equals $D$. The numbers below the line are the side cuts or fills, or the distance above or below the grade line of the surface of the ground at the slope stakes. When it is



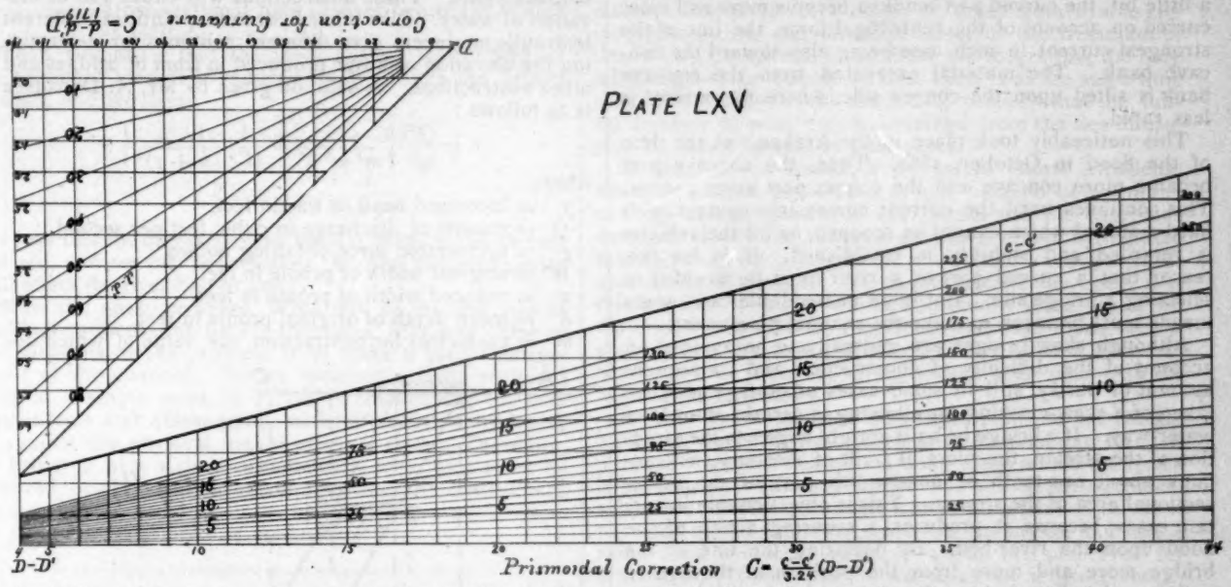
*Triangular Prisms* $M = \frac{50\,C}{54}D$ PLATE LXIV

desired to make the estimate with a degree of exactness that necessitates the use of the prismoidal correction, the amount of this correction which can be taken at once from a diagram similar to Plate LXV should be taken for each station, and these various amounts recorded opposite the respective stations in a column. Then by the use of a diagram similar to Plate LXIII, constructed from equation 4, with the required width of road-bed and angle of slope, the contents of the different prisms can at once be read off. Before this is done, however, the values of $D$ should be determined (by taking the sum of $d$ and $d'$). Then for any one station find the vertical line representing the value of $D$ of that station, and follow it up until it cuts

the inclined line representing the value of $C$ of that station, and read off the required value of $M$ from the horizontal line intersecting at the same point.

The value of $M$ as given by equation 4 is only for prisms 50 ft. long, and the sum of any two adjacent prisms will give the cubic contents of the entire station. From this total must be subtracted, if any, the amount of the prismoidal correction, in order to obtain the true value of $M$.

When a cut or fill occurs upon a curve of sufficiently short a radius to necessitate the correction for curves, this correction, which is a correction in the length of $d$ and $d'$,




should be taken from a diagram similar to that in Plate LXV, and the corrected values of $d$ and $d'$ written below the actual values, and the sum of the corrected values are what should be used with Plate LXIII.

(TO BE CONTINUED.)

## NOTES ON RIVER CROSSINGS AND BRIDGE PIERS.

BY M. OTAGAWA, M.E., TOKYO, JAPAN.

(*Continued from page* 495.)

### IV.—EFFECT OF OBSTRUCTIONS TO RIVER DISCHARGE.

IN narrowing the regimen of a river by bridge piers, a certain amount of obstruction to the river discharge is made. The equilibrium of the regimen in any part of a river is established between the abrasive energy of a river current and the cohesive strength of the materials which compose the bed of the river in the section in question. If now any obstruction, such as a bridge, be formed in the regimen, then the force with which the water acts on the bed is increased and a new equilibrium is established. What was lost in width by the bridge piers is to be regained by depth. This being the case, after a bridge has been built, the river will compensate for its lost area by scouring away its depth. Again, on the other hand, if by any cause the velocity of a river be diminished, there will be formed deposits on the bed. Therefore in bridging over a river we must know the velocity of the river at the site and the probable augmentation by the contraction of the channel. The latter must not be so great as to corrode the river-bed and destroy the foundations of the piers and abutments.

First, let us suppose that the material is very compact and tenacious, as in the case of rock. In this case, however great the velocity may be, water cannot attack the bed, and as far as the bridge is concerned it is quite safe. But as the water cannot acquire a great velocity, an eddy is formed above the bridge and the water will overflow. Next, suppose that the material under consideration is such that it easily yields to the action of water, as in the case of mud or sand; then precautions must be taken to prevent scouring taking place in one part of the bottom under the bridge and silting up on other parts, when the velocity is increased by the construction of a new bridge.

In determining the actual bottom velocities of rivers of considerable depth, it is not possible to place stationary current meters sufficiently deep. In some cases the bottom velocity varies considerably with the depth, even when the mean velocity remains constant. In a deep portion of a river water flows with more uniform velocity, but in a shallow part there is a marked difference between the greatest and least velocity. Dr. Rankine's formula giving the relation between bottom and mean velocity is this: The bottom velocity is as much less than the mean velocity as the surface velocity is greater than the mean.

Let $m$ = mean velocity in feet per second;
$v$ = surface " " " "
$b$ = bottom " " " "
Then $b = 2m - v$.

It has been found by experience that the above rule gives an excessive value for the bottom velocity.

The force of impact of water upon materials obstructing the stream is directly proportional to the square of the velocity, and the resistance of the same material is proportional to their submerged weights, or as the cubes of their linear dimension (if the shape be similar).

Let $V_1$ and $V_2$ be the velocities of flow; $W_1$ and $W_2$ their weights in water; and $D_1$ and $D_2$ the similar dimensions of stones, which are just moved by the velocities $V_1$ and $V_2$ respectively.

Then we have:

$$V_1 : V_2 :: W_1 : W_2 :: D_1^3 : D_2^3$$

Thus, knowing the size and weight of a stone of a given form and specific gravity which will be just moved by currents of a certain velocity, we can calculate those for another stone of the same form and specific gravity which will be moved by a different velocity. However, this method is rather theoretical. A number of experiments has been made by different hydraulic engineers. Without going into further details, it will suffice to state the results of recent observations by Chief Engineer Sainjon in the River Loire. The results in English measures are as follows:

| | | | | |
|---|---|---|---|---|
| Velocity in feet per second, | 1.64 | 3.28 | 4.92 | 6.56 |
| Diameter of stone in inches, | 0.40 | 1.60 | 3.90 | 6.70 |

The Mississippi and Missouri observations show that at the time when the inundation of the rising water takes place and spreads over the forelands, the bottom velocity is diminished and silt is deposited. As far as stability is concerned, a rocky bed is best; where the bed consists of gravel it is stable in an ordinary flow of water, but not stable in flood. When the bed consists of earth, the condition is such that it is just stable and no more, or permanently unstable. When the banks and the bottom are in the last-mentioned condition, the river channel constantly changes both in form and position, which is the case for rivers running in alluvial soil. A slight obstruction makes a straight channel curved. As soon as the bank is scooped a little bit, the curved part tends to become more and more curved on account of the centrifugal force, the line of the strongest current in such case being also toward the concave bank. The material excavated from the concave bank is silted upon the convex side, where the current is less rapid.

This noticeably took place in the Arakawa at the time of the flood in October, 1882. Thus, the concave part became more concave and the convex part more convex. This continues until the current comes into contact with hard material which cannot be scooped, or till the velocity is retarded and stability is established. It is for this reason that a curved part of a river must be avoided in selecting a bridge site. But in an unavoidable case, some means must be taken to make the channel permanent.

Although skew-bridges are generally to be avoided on account of the difficulty of construction and consequent amount of outlay, still in some cases advantage may be taken of a skew-crossing for allowing a certain amount of water-way. If a bridge be built at right angles to the direction of the stream, the piers, if built of masonry, will occupy about one-tenth or one-twelfth part of the cross-sectional area of the stream. This is objectionable in certain cases, because it produces a scouring action of the flood upon the river-bed. By deviating the line of the bridge more and more from the position of the square crossing, the disturbance of a stream by the bridge pier will gradually become less, and we will meet with such a case that in any square section, one and only one pier obstructs the current. This can be better answered by diminishing the thickness of the pier as much as possible, and the problem can be solved as follows:

The accompanying sketch (fig. 4) shows the arrangement for crossing a river by the above-mentioned principle. $A\,C$ and $D\,E$ are the banks of a river. $P\,Q$, $R\,S$ and $T\,U$ are the piers, and they are so arranged that the projections of the ends of two consecutive piers such as $Q$ and $R$ on the bank $D\,E$ are in the same point.

Let
$B$ = breadth of river on square;
$a$ = angle of skew;
$b$ = breadth of pier on skew;
$s$ = span of pier on skew;
$n$ = number of spans;
$n-1$ = number of piers.

Then we have $\frac{n\,s}{B} = \text{cosec. } a$;

or $s = \frac{B}{n}\text{cosec. } a$.

$$\frac{B}{n\,b} = \tan a;$$

$$n = \frac{B}{b \tan a}.$$

If $a = 70°$ (the limiting angle of obliquity),

$$\tan a = 2\tfrac{3}{4} = \tfrac{11}{4}$$

$$\therefore n = \frac{4}{11}\frac{B}{b}$$

In the above equation $B$ is a constant quantity, being the breadth of a river; $b$, being the breadth of pier, depends upon the amount of traffic. The nearest larger whole number obtained from the above equation fixes the best number of spans, as far as the reduction of obstruction is concerned. But it will not be the number from the point of economy, the best number for which depends upon the difficulty of founding piers. The suitable length of span and the consequent number of piers should be selected to suit the nature of the particular circumstances.

### V.—HEIGHT OF EDDY CAUSED BY PIERS AND OTHER OBSTRUCTIONS.

Having so far considered the subject of the resistance of materials to the flow of water, the next problem is to make an approximate computation of the new velocity and the increased head which will be formed when cross-section the river is contracted by the piers, abutments, and embankments. These obstructions will cause a *local* elevation of water. Like other hydraulic quantities, different hydraulic engineers give different solutions for determining the elevation of water produced in front of bridges and other obstructions. A solution given by Mr. A. Debauves is as follows:

$$y = \frac{Q^2}{2g}\left\{\frac{1}{m^2 w^2 h^2} - \frac{1}{W^2 (h+y)^2}\right\};$$

where
$y$ = increased head or rise in feet.
$Q$ = volume of discharge in cubic feet per second.
$g$ = accelerated force of falling bodies.
$W$ = original width of profile in feet.
$w$ = reduced width of profile in feet.
$h$ = mean depth of original profile in feet.
$m$ = coefficient for contraction, the value of which depends chiefly upon the width of the piers, the form of starlings, and springing of arches.

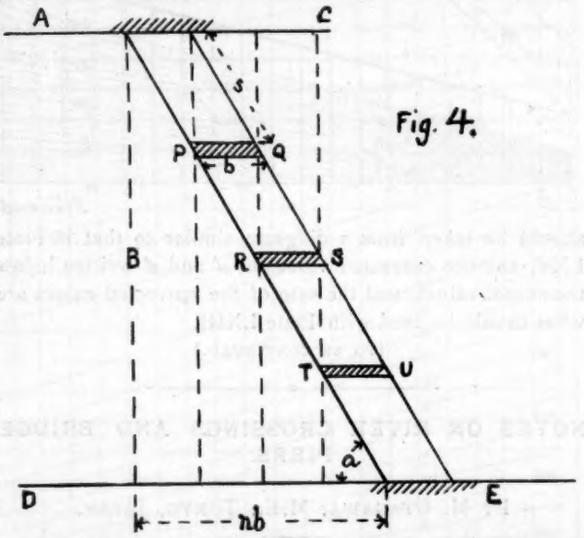



Fig. 4.

Although the values of $m$ may not have been fixed with exactness, the following values will not cause any material error so far as the data are concerned.

$m = 0.75$ when the piers are terminated by a semi-circle or by acute angles.

$m = 0.90$ when the piers present an obtuse angle to the current.

$m = 0.85$ when the piers have square heads, the arches being large.

$m = 0.70$ when the arches are small and their springings are submerged in water.

The distance from the bridge to the point where the eddy extends cannot be accurately ascertained. But according to Mr. D. Aubuisson, in an ordinary river of nearly uniform regimen the elevation above the original slope line takes place as far up as expressed by the following equation:

$$D = 1.9 \times \frac{y}{s};$$

where $D$ = distance in feet.
$y$ = rise at obstruction in feet.
$s$ = original slope.

These formulæ give only a rough idea of the increased head caused by the obstruction and the extent of it. An

instance may be given in connection with a railroad bridge over the River Tone in the Tokyo-Utsunomiya line. In February, 1884, when the bridge was to be constructed by founding 13 piers consisting of brick wells of 8 ft. in diameter, people in the locality feared that the local elevation of water and the extent of it would be great. But it is calculated that the local elevation is from 3 in. to 4 in. only, and it extends through the distance of 2,160 ft.

Having determined the value of $y$, the local elevation of water in front of the piers, we can calculate an approximate value of an increased velocity as follows:

Let $Vi$ = increased velocity in feet per second.
$V$ = original velocity in feet per second.
$B$ = breadth of river in feet.
$A$ = cross-sectional area of river before the bridge is built.

Then, supposing that the piers occupy 10 per cent. of the sectional area, it is reduced to $\frac{9}{10} A$ after the bridge is built, and we have

$$VA = Vi\left(\frac{9}{10}A + By\right)$$

$$\therefore Vi = \frac{10\,VA}{9\,(A + By)}$$

From this the corresponding bottom velocity can be calculated, and we can see whether the new bottom velocity will affect the river-bed or not.

Now the question arises, What will be the best way of making compensation for the increased velocity? One of the solutions of the problem is to make a local enlargement of the channel. But to maintain a large sectional area at a single point in a river while keeping the area both above and below small, without continual dredging, is against the physical nature of every river. Therefore, in bridging over a river, a sufficiently wide part must be selected, or else some means of reducing the obstruction, such as a skew-crossing, must be made.

(TO BE CONTINUED.)

## THE TREATMENT OF TIES ON AUSTRIAN RAILROADS.

(H. Karplus, in the Vienna *Zeitschrift fur Eisenbahnen und Dampfschiffahrt.*)

IN taking up a subject which has already been much discussed by engineers, we propose in this paper not only to prove once more the excellent effects to be derived from the treatment of railroad ties and timber, and to show the excellent financial results obtained for a series of years, but also to add to previous testimony the latest results obtained in practice, and at the same time to point out the great economic value of the processes which lengthen the life of ties and other timber, and, by thus decreasing the yearly demand for renewals, lessen the draft upon the growing forests, prevent their devastation, and act indirectly but most favorably upon the meteorological and other conditions affecting the sources of the streams and rivers.

Both from the point of view of railroad management and from that of the general economic condition of the country, it is thus a pressing duty to recommend the adoption of preservation processes to all interests using timber largely, and especially to the railroads, which are now the largest consumers.

If we speak here chiefly of the treatment of ties, it is because they form the larger part of the consumption, because upon them the treatment has the greatest effect, and because there is attainable for them full and exact statistics extending over a series of years. It is self-evident, however, that any process of treatment which increases the resistance of ties to decay and atmospheric influences can also be used for other timber with the certainty that it will increase its durability under similar circumstances, and that no different arguments need be used to show that it is desirable.

As further proof we may mention the fact that the Post and Telegraph management has for a number of years used telegraph poles treated by preserving processes, and so far the results have been excellent. It may also be noted that on the lines of the Austrian State Railroad the timbers of the wooden highway-crossing bridges have been treated as far as possible, though in this case the use of these processes has been somewhat limited by the size of the boilers or impregnating vessels used, which are generally not over 10 meters (32.8 ft.) in length.

We are still in Austria fortunately so situated that in most places and neighborhoods timber and ties can be cheaply obtained. The only question to be considered by our railroad managements is, therefore, whether the treatment of ties, which costs money, is now profitable.

If we are now at a point where prices are so low, in consequence of an over-supply or other unfavorable circumstances, that the financial effect of the treatment of ties is only questionable, we must not forget that the only advantage to be gained—unless there is at the same time care taken to protect the remaining timber—that the fullest amount of work can be obtained from the ties in use, may be dearly bought in later years.

In practice we should, if we would follow a rational business course, preserve a proper balance between the average annual growth of our forests and the enormous demand, chiefly for railroad purposes, remembering also that this demand is largely for the better and more valuable kinds of timber. We cannot escape the belief that this law has been and will be continually more and more violated, if we refer to experience and have found that in many places the new growth of timber on land that has been cut over does not by any means keep pace with the destruction of trees.

In later years we have also taken pains to use certain kinds of wood for ties, which were unavailable for that purpose when not treated. Among these woods the beech is prominent. This application has shown such good results that in future, through treatment, an excellent use is provided for an abundant wood like the beech, and at the same time the more valuable woods are preserved for other uses. It may also be noted, as an indirect result, that for many years to come the value of land growing beech trees will be increased.

The treatment of timber has been in practical use over 40 years now, and much has been written on this subject, both in relation to methods and results. We might mention the names of Funcke, Buresch, Bischoff and many others.

In order to enforce these views the experience had on the Austrian railroads has been collected, and is shown in the accompanying table. In this table are shown the results obtained with ties of different kinds of wood treated and not treated, for periods varying from 13 to 18 years. The figures show the total percentage of the entire number laid which had been removed and replaced by new ones at the close of each year, and the results are very striking. Thus with untreated beech we find that no less than 5 per cent. had to be replaced the first year, 10 per cent. the second, and 25 the third, while by the end of the fourth year all the remaining 60 per cent. had been taken out. The same wood, treated by the sulphate of copper process, shows widely different results, so that at the end of the fifteenth year no less than 27 per cent. of the ties remained in the track. The results shown, extending over a long period, are very favorable.

If the details of the table are carefully examined, it will be seen that experience shows, almost without exception, that *the less the resistance which any wood in its unprepared condition opposes to decay, the greater is the comparative effect of preservative treatment.*

This result finds its explanation in the fact that in all the methods of treatment the soft woods take up during the process twice, and in some cases three times as much of the antiseptic preparation as the harder and closer-grained woods.

We may note especially, as shown in the table, that the effect of treatment on fir ties is excellent, and that the average life of preserved fir ties is much greater than that of the untreated oak ties. While with untreated fir more than half the ties were removed at the end of the eighth year, and all had been replaced in 12 years, at the end of

LIFE OF TIES ON AUSTRIAN RAILROADS.

| Kind of Wood. | Treatment. | Number Laid. | TOTAL PER CENT. REMOVED AT THE END OF ——. | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 Yr. | 2 Yrs. | 3 Yrs. | 4 Yrs. | 5 Yrs. | 6 Yrs. | 7 Yrs. | 8 Yrs. | 9 Yrs. | 10 Yrs. | 11 Yrs. | 12 Yrs. | 13 Yrs. | 14 Yrs. | 15 Yrs. | 16 Yrs. | 17 Yrs. | 18 Yrs. |
| Beech | None | ..... | 5 | 15 | 40 | 100 | ... | ... | ... | .... | .... | .... | ... | .... | .... | ... | .... | ... | .... | ... |
| Beech | Sulphate of copper | 1,871,200 | .... | 1 | 1½ | 5 | 11 | 19 | 27 | 34 | 40 | 47 | 53 | 59 | 65 | 70 | 73 | .... | .... | .... |
| Pine and fir | None | 100,000 | 1 | 3 | 10 | 33 | 75 | 92 | 100 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| Pine and fir | Chloride of zinc | 32,910 | .... | 1 | 2 | 4 | 12 | 21 | 30 | 38 | 47 | 56 | 65 | 73 | 82 | 90 | .... | .... | .... | .... |
| Pine and fir | Creosote | 19,450 | .... | ... | .... | .... | 0½ | 2 | 5 | 9 | 14 | 18½ | 27 | 38½ | 52 | 65 | 75 | 84 | .... | .... |
| Fir | None | 880,000 | .... | 2 | 5 | 10 | 18 | 29 | 41 | 55 | 68 | 81 | 94 | 100 | .... | .... | .... | .... | .... | .... |
| Fir | Chloride of zinc | 491,400 | .... | .... | .... | .... | 0½ | 1 | 3 | 5½ | 10 | 15½ | 21½ | 28 | 34½ | 40½ | 47½ | 53½ | 59½ | 65 |
| Fir | Creosote | 83,600 | .... | .... | .... | .... | 0½ | 1 | 3 | 4 | 6 | 9 | 12 | 21½ | 26 | 30½ | 35 | .... | .... | .... |
| Larch | None | 355,500 | .... | 0½ | 1 | 1½ | 2 | 6 | 16 | 28 | 42 | 58 | 72 | 81 | 88 | .... | .... | .... | .... | .... |
| Larch | Chloride of zinc | 970,735 | .... | .... | .... | .... | 0½ | 2 | 5 | 9½ | 17 | 26 | 34 | 43 | 52 | 62 | 73 | .... | .... | .... |
| Larch | Creosote | 14,840 | .... | .... | .... | .... | 0½ | 1 | 3 | 5 | 9 | 14 | 21½ | 30 | 40 | 51 | 62 | .... | .... | .... |
| Oak | None | 115,790 | ... | .... | .... | 0½ | 1½ | 3 | 7 | 13 | 23 | 34 | 44 | 56 | 68 | 80 | 89 | .... | .... | .... |
| Oak | Chloride of zinc | 529,564 | .... | .... | .... | .... | 0¼ | 0¾ | 1 | 4 | 9 | 17 | 24 | 31 | 37 | 41½ | 44 | 46 | . . | .... |
| Oak | Creosote | 302,290 | .... | .... | .... | ... | 0¼ | 0½ | 1 | 1½ | 3 | 7 | 13½ | 20½ | 27 | 33½ | 38 | 41½ | 45 | .... |

18 years no less than 35 per cent. were still in service. Or, contrasting the treated fir with the untreated oak, at the end of the fifteenth year there had been removed only 47½ per cent. of the former against 89 per cent. of the latter. This result is so much the better for the reason that a fir tie which has had preservative treatment costs less than an untreated oak tie.

It may be added that, as a result of the favorable experience had, the Southern Railroad has put in about 2,000,000 prepared beech ties, and that the State Railroad has, for four years past, been putting in a large number of treated beech ties, the results so far having been very good.

Other woods show excellent results. It may also be noted that the facts given in the table show that the common opinion that it will not pay to treat oak ties is without foundation. In addition to the financial gain there is the further advantage that the treatment of the oak ties not only makes the ties themselves more durable, but it also helps to preserve a valuable wood which is already growing scarce. The same may be said of larch.

We have thus shown in as condensed a manner as possible that on the Austrian railroads the results of the preservative treatment of ties have been exceedingly good, so that the statement of the observations made of the conduct of several million of ties over a series of years should be enough in itself to obviate the necessity of any further argument. It may be added that experience on German railroads shows equally good results.

At this point it may be suggested that the railroad managements, with the object of showing treated ties of the oldest dates, should have such ties taken from the roadbed and sections of them brought to a convenient place for exhibition. Such an exhibition would form an excellent pendant to the statistical table, and would be the more interesting as it would include soft wood ties of 16 and 18 years' endurance.

By the end of 1888 there will be on the Austrian railroads about 22,056,000 ties, of different kinds of wood. Of these about 7,683,000—35 per cent.—are treated, and the remainder—14,373,000, or 65 per cent.—are not treated.

Of the 7,683,000 prepared ties, 64.2 per cent. were treated with chloride of zinc after the Burnett system; 18.4 per cent. with creosote on the Bethel, Blythe, or Paradis, and 17.4 per cent. with the sulphate of copper process.

In recent years the cost of treating ties has been diminished by the use of portable apparatus and by the abolition of the permanent plants, thus doing away with the cost of carrying the ties to and from the place of treatment, and by the relatively lower cost of the apparatus itself does not put too heavy a charge on the smaller roads. Thanks to these circumstances, the cost of treatment is lower than for 15 or 20 years past, and now stands at hardly more than 22 to 30 kreuzer (8 to 11 cents), or at most 40 kreuzer (15 cents) per tie.

As to the introduction of iron superstructure in Austria, it is not to be thought of for a long time yet, partly because of the low price of wooden ties, but chiefly on account of the relatively high price of iron.

So long, however, as we can supply ourselves with wood, and can increase its durability as much as possible by preservative processes, we need not be troubled by any fear that we will suffer from a lack of ties or from the high cost of the introduction of iron or steel superstructure.

## NOTES ON STEAM HAMMERS.

By C. Chomienne, Engineer.

(Translated from the French, under special arrangement with the Author, by Frederick Hobart.)

(*Continued from page* 504.)

### CHAPTER XXIII.

### THE MASSEY DOUBLE-ACTING HAMMERS.

The Massey Brothers, of Openshaw, near Manchester, in England, have made their works specially noted for the construction of small hammers, and have sold a considerable number of these tools, of a series of types, in all parts of the world.

It might be said that this firm has done more than any other to bring these tools into general use, by varying their designs according to the work which they were called upon to do.

All their hammers, the weight of which varies from 25 kilos. up to 20 tons, are distinguished by solidity of structure, and by the simplicity of their working parts. They are all double-acting, and are generally made automatic up to 500 kilos.; above this weight they are managed by hand.

The accompanying illustrations show a hammer of 200

Fig. 81.

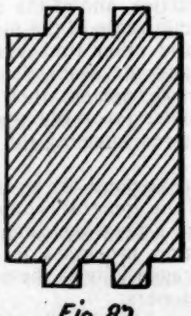


Fig. 82

kilos., fig. 76 being a front view, fig. 77 an elevation, fig. 78 a plan, and fig. 79 a section on a larger scale.

There is nothing particular to note about the foundations; the anvil-block is independent, and the ratio between its weight and that of the working parts is 8 : 1; this ratio seems to us too small, as it should be at least 12 : 1, and by this higher ratio we would avoid the shocks which take place when the maximum stroke is used, and would better utilize the work produced.

The frame is in two parts, fastened by heavy bolts to the foundation plates and supports above the steam cylinders,

This arrangement allows the piece to be forged to be handled in every direction.

The hammer, which is well guided by the slides, is of wrought iron or of steel; above 500 kilos. these hammers are generally made of open-hearth steel.

The rod and the piston are of steel and forged in one piece; the lower part of the rod ends in a cone, which enters the hammer and is held by a semi-cylindrical key, the flat side of which is driven on a plane inclined to the rod, thus preventing all movement.

This hammer owes its success to the facility with which the stroke is regulated and the simplicity of its parts.

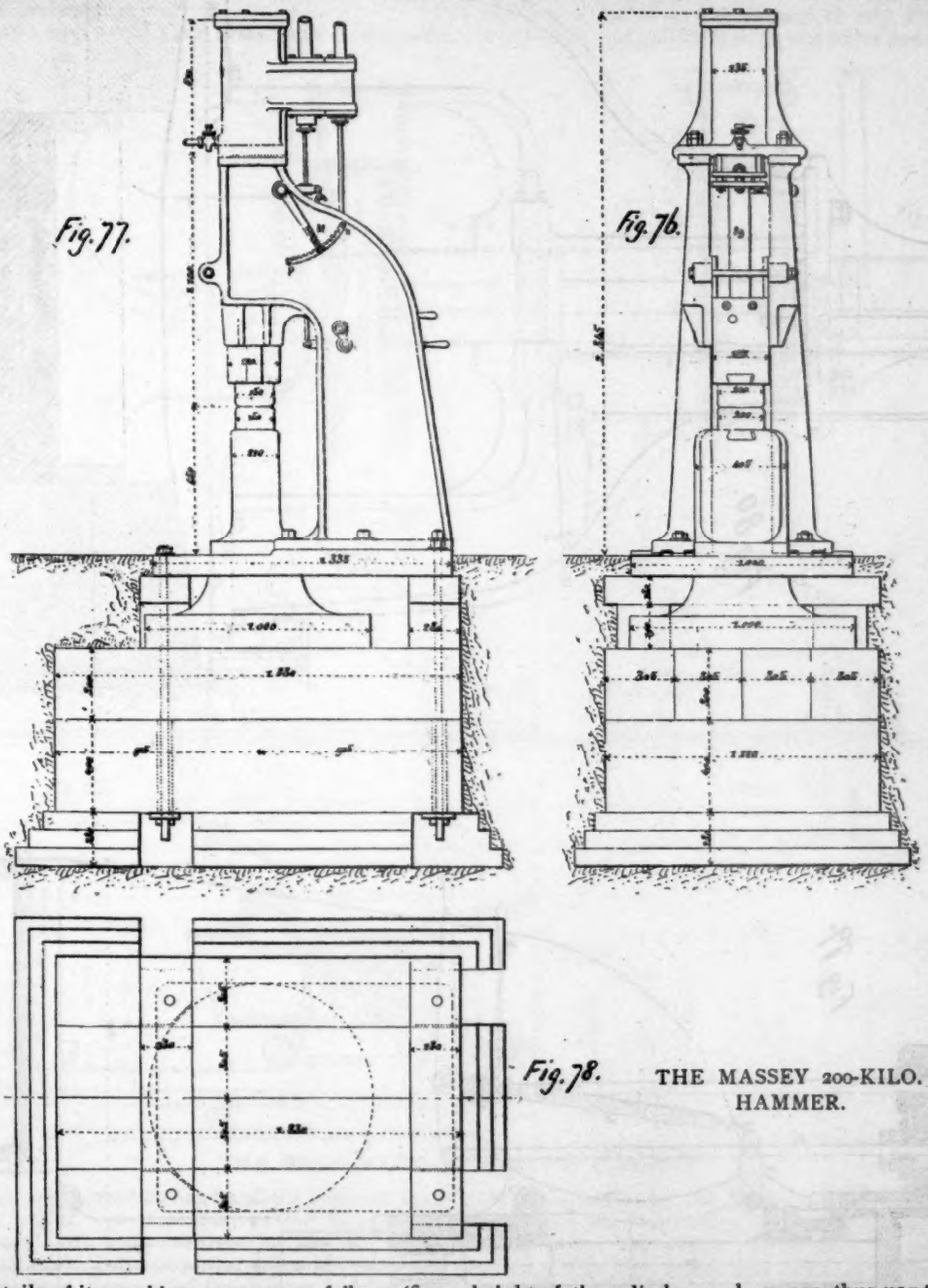


Fig. 77.

Fig. 76.

Fig. 78. THE MASSEY 200-KILO. HAMMER.

Some of the details of its working parts are as follows (fig. 79):

*A* is the steam valve worked by the lever *B*.

*G* is a circular balanced valve for distribution of steam; it has no packing, as the expansion of the bronze of which it is made is greater than that of cast iron; this is sufficient to make a tight joint.

*D* is the valve rod, which can be moved by hand through the lever *Q*.

*J* is a projecting lug or cam fixed to the hammer; when the piston rises this cam slides along the curved lever *J*, throwing it back, and by means of the arm *K* lifting the valve-rod *D* and the valve *G*. This movement allows steam to enter the upper part of the cylinder, and thus causes the piston and the hammer to descend. The spring *L* throws back the lever *J*, the rod *D*, and the valve *G* to their former places in such a way that the movement of the hammer is carried on without shock or concussion.

*M* (fig. 77) is a lever at the side which serves to regulate the stroke of the piston; when placed at *n* the lever *M* raises the lever *J* through the shaft on which the latter oscillates; in this case the piston has only a short stroke, and if this lever is placed at *p* the piston rises to the full height of the cylinder, and we can thus use the maximum stroke.

*Q* is a hand-lever, which is not used when the hammer works automatically, but when it is necessary to strike a dead blow with all the force available, this lever is thrown down by a short movement of the hand; while it is held down the steam continues to press upon the piston; this lever is thrown back at once by the spring *L*, when the hand is removed, but this spring should be stiff enough to keep the lever *J* always in contact with the cam.

If by chance the piston strikes the cover *F* of the cylinder

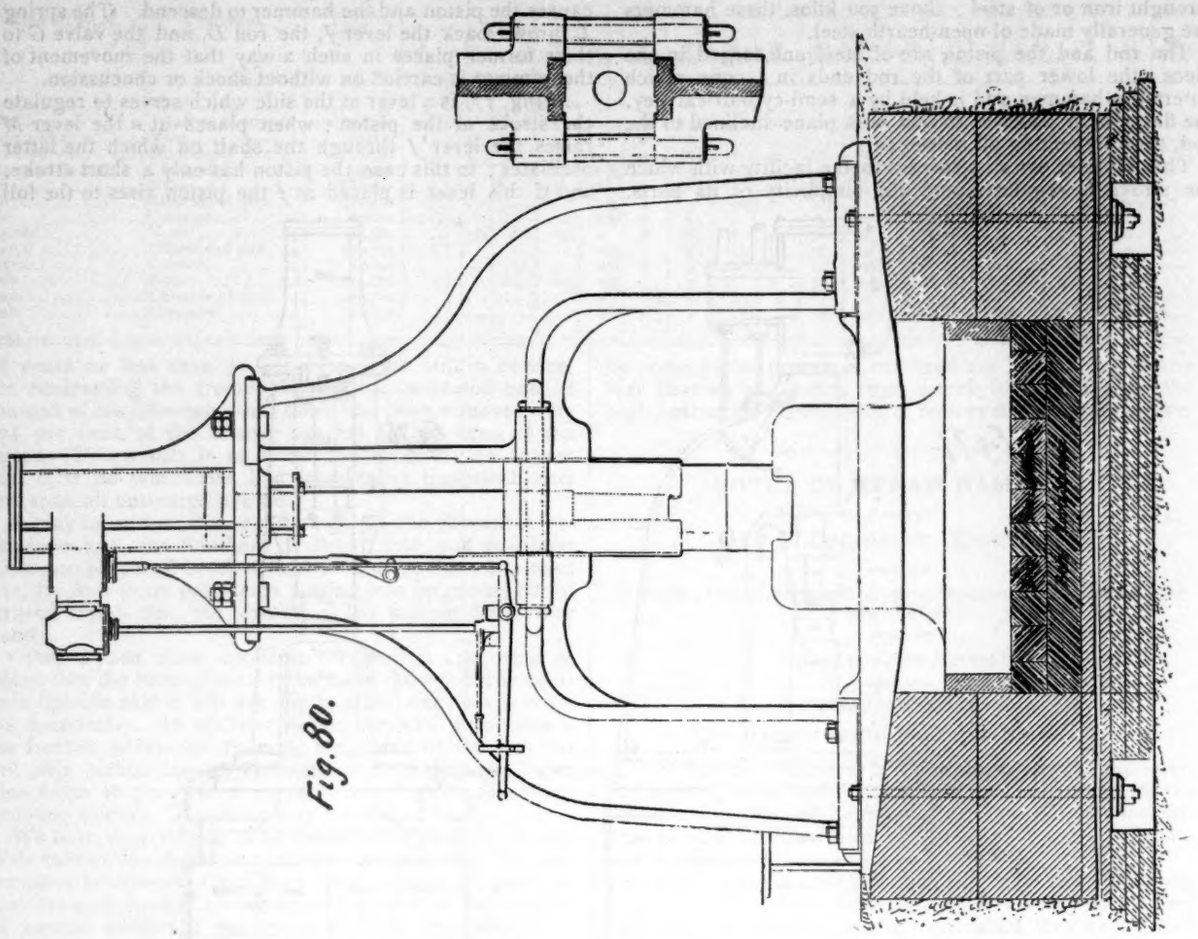


Fig. 80.

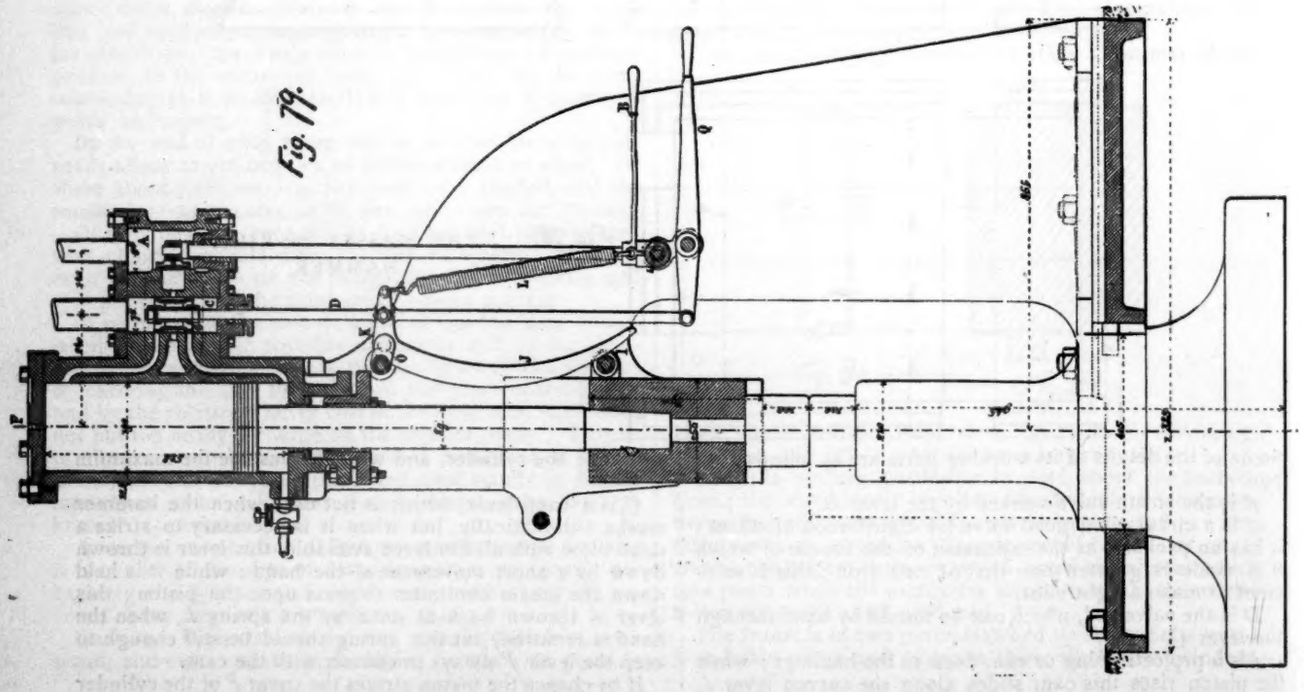


Fig. 79.

the trouble may be done away with at once by lightly raising the valve *D* upon its rod. It is sufficient for this purpose to place upon the ring *C*, shown in fig. 81, a washer ½ mm. in thickness, or to change the ring by making it a little thicker. In the lower part of the cylinder is a small cock, which serves to carry off all the water of condensation.

The Masseys also build hammers of the same type, but with frames of wrought iron; each leg of the frame consists of two plates solidly braced together, which enables them at once to reduce the weight considerably and to increase the resistance, so that there is no reason to fear trouble caused by breakage.

Fig. 80 shows a hammer of 1,000 kilos. built by the same firm; the valves are worked by hand and the hammer used to forge large pieces. In this hammer the form of the frame, while not quite so convenient for the use of the hammerman as that of the 200-kilos. hammer, has been chosen by preference because of its greater rigidity and resistance to the heavy shocks, resulting from the forging of pieces of large dimensions.

The joints of the foundation plates and of the frame are carefully finished and adjusted, and the legs of the frame are joined and braced below the slides by two heavy bolts.

In many of these hammers above 500 kilos. the guides are made with two shallow grooves in which the hammer works, thus giving a sufficient bearing surface without weakening the frames. A section of this hammer-block is shown in fig. 82.

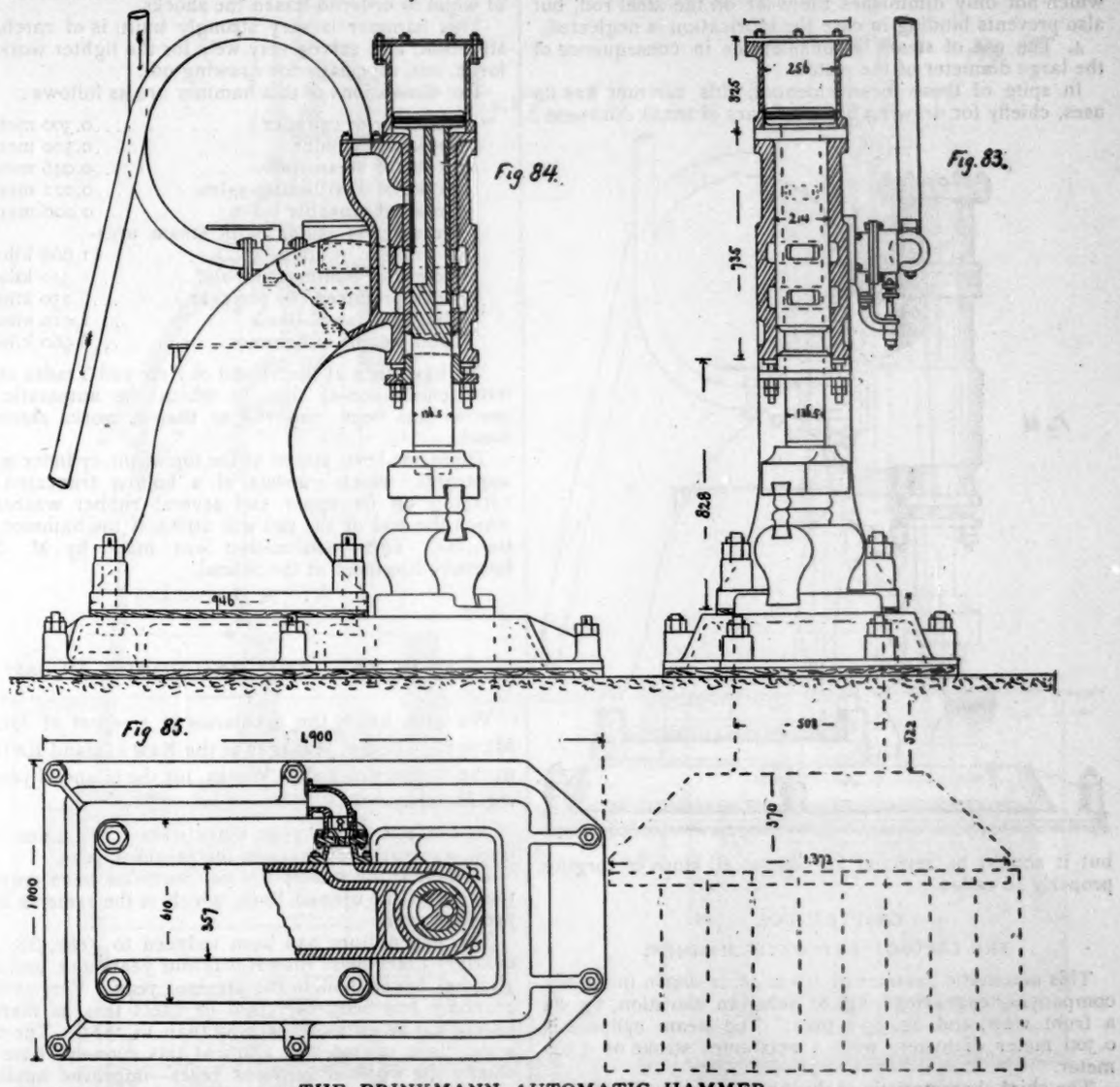
This type of hammer serves very well indeed almost all the purposes of the forge.

## CHAPTER XXIV.

### THE BRINKMANN AUTOMATIC HAMMER.

Figs. 83, 84, 85, and 86 show a hammer of 200 kilos., made by the firm of Brinkmann & Company at Witters-ander-Ruhr, Westphalia; fig. 83 being a front view; fig. 84 an elevation, showing a section of the cylinder; fig. 85 a plan, and fig. 86 a full side view of the hammer.

The advantages of this class of hammer are found especially in the simplicity of the distribution of steam. The machinery for it is not subject to any disarrangement, while there are neither valves nor valve-rods. The distribution is made by the piston-rod of the hammer itself, which has two longitudinal openings, one serving to admit steam below the piston and raise it, the other to admit steam above the piston and cause it to descend, and to increase at the same time the intensity of the blow. The stroke is limited by the slight lead given to the exhaust for the steam which acts below the piston, and to the admission of steam above the piston.




THE BRINKMANN AUTOMATIC HAMMER.

This hammer, as will readily be seen from a study of the drawing, is very simple, and can hardly get out of order.

The drawbacks to the use of these hammers are as follows:

1. They can only be used for short strokes and comparatively small power.

2. They cannot be used to give a quick stroke with a light blow, for with a higher pressure of steam the speed necessarily increases in the same ratio as the pressure above the piston, and the maximum blow is then reached.

3. The surface of the piston raising the rod should be at least one square centimeter per kilogramme of the weight to be lifted; the pressure of steam should be at least 4 kilos., for below that pressure the speed of the hammer decreases very rapidly, allowance being made for the considerable amount of work absorbed by the friction of the stuffing-boxes on the rod itself. The packing of these is not easily kept tight, and the leakage is considerable; for this reason the original packing or lining of the cylinder, which was of cast iron, has been replaced by one of bronze, which not only diminishes the wear on the steel rod, but also prevents binding in case the lubrication is neglected.

4. The use of steam is considerable in consequence of the large diameter of the piston.

In spite of these inconveniences, this hammer has its uses, chiefly for drawing out steel bars of small thickness;

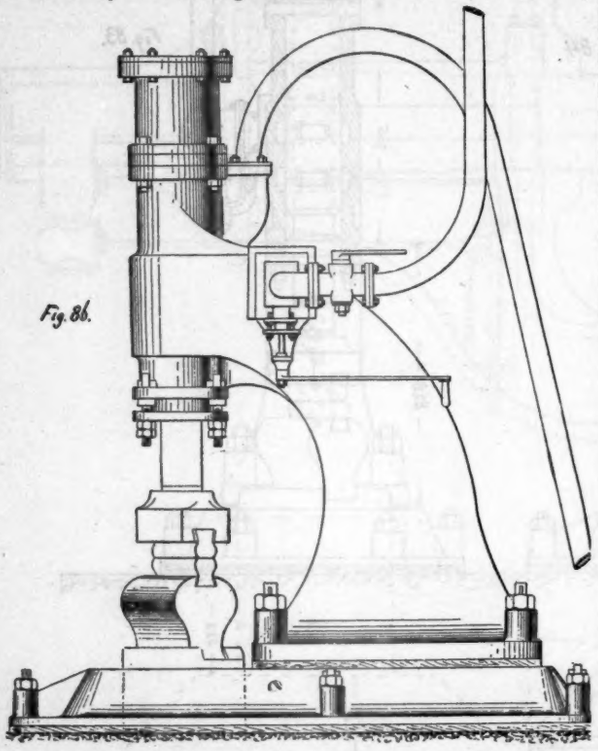


Fig. 86.

but it should be rejected for almost all kinds of forging properly so called.

## CHAPTER XXV.

### THE CREUSOT AUTOMATIC HAMMER.

This automatic hammer of 250 kilos. is shown in the accompanying engravings, fig. 87 being an elevation, fig. 88 a front view, and fig. 89 a plan. The steam cylinder is 0.300 meter diameter, with a maximum stroke of 0.500 meter.

The chief characteristic of this hammer is the method of the distribution of steam, which is made by a flat balanced valve. The motion is obtained from a square block fixed upon the upper end of the piston-rod. This block carries an arm with a pin, which works in a link forming the vertical arm or lever of a bell-crank, the horizontal arm of which works, through two small connecting rods, the rod carrying the distributing valve.

The intensity of the blow and the stroke of the hammer can be changed by a lever which moves a valve placed between the distributing valve and the port opening into the cylinder, the object of which is to reduce the section of the steam-port.

Steam is admitted to the steam-chest taken through a flat horizontal valve worked by a lever placed conveniently to the hammerman's hand.

The piston and the rod are made in a single piece; the lower part of the rod, which enters the hammer-block, is conical, and is fixed in the block by a simple key.

The rod is extended above the piston by a circular section of the same diameter as the lower part, but there are on it two flat places, which, passing through the stuffing-box placed at the top of the cylinder, prevent any rotary movement.

The foundations of the hammer consist of a block of beton having a large surface and of two rows of oak timbers, upon which the frame rests. The anvil-block is a simple, rectangular truncated pyramid, resting in the central part of the hammer frame on two layers of oak timbers, and fixed in its proper position by wedges which are made of wood in order to lessen the shocks.

This hammer is very strongly built, is of careful construction, and serves very well for the lighter work of the forge, and especially for drawing out.

The dimensions of this hammer are as follows:

| | |
|---|---|
| Diameter of cylinder | 0.300 meter |
| Stroke of cylinder | 0.500 meter |
| Stroke of steam valve | 0.046 meter |
| Stroke of distributing valve | 0.022 meter |
| Stroke of movable valve | 0.020 meter |
| Pressure on piston, with steam pressure of 3 kilos | 1.668 kilos. |
| Weight of hammer and rod | 312 kilos. |
| Work produced (80 per cent.) | 250 kilos. |
| Weight of anvil-block | 1,012 kilos. |
| Total weight of hammer | 8,960 kilos. |

We have seen at the School of Arts and Trades at Aix a hammer similar to this, in which the automatic valve motion has been removed so that it works entirely by hand.

There has been placed at the top of the cylinder a safety apparatus, which consists of a hollow truncated cone, carrying on its upper end several rubber washers, on which the end of the rod will strike if the hammer raises too far. This modification was made by M. Coron, formerly Engineer of the School.

(TO BE CONTINUED.)

## NEW ZEALAND RAILROADS IN 1887.

WE give below the substance of a report of Mr. J. P. Maxwell, General Manager of the New Zealand Railroads, to the Minister of Public Works, for the financial year ending March 31, 1888:

At the end of the year there were 1,758 miles of line open, against 1,727 miles in the previous year.

Interest at the rate of 2.3 per cent. has been earned on the cost of the opened lines, which is the same as for the previous year.

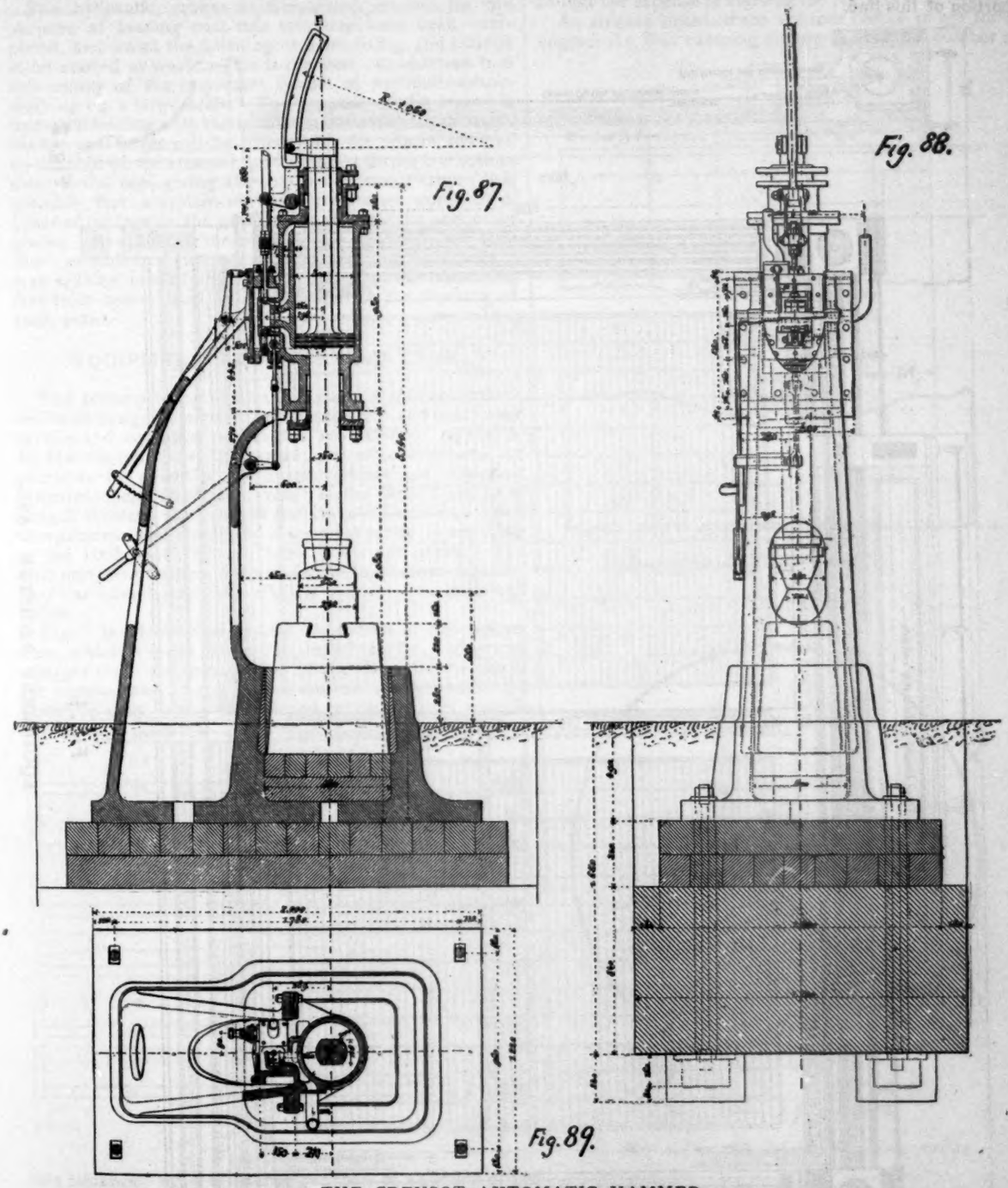
The expenditure has been reduced to £687,328, being nearly £3,000 lower than it was four years ago, and nearly £12,000 lower than in the previous year. Very stringent economy has been exercised to effect this, as there are nearly 300 miles more railway than in 1885. The means which have operated to allow of this economy have been chiefly the work of previous years—improved appliances introduced, saving labor in the shops; better engines introduced to take heavier loads, effecting savings of labor thereby; improvements in the roads due to better rails, sleepers, drainage, and a more permanent condition of the bridges gradually effected under maintenance; improvements in the locomotives, leading to diminished consumption of fuel; and finally the close head-office scrutiny exercised, and the intelligent and close application of the local officers.

On the average we are able to work with nearly 200 less hands than was the case in 1884-85.

It is to be regretted that the traffic has remained practically stationary since last year; this is largely due to a late harvest, and to grain being held for more favorable sea freights. While the tonnage is slightly lower, the traffic work done is slightly greater than in the former year, the

average distance traffic has been carried being greater. The wool traffic shows a moderate increase. The fact that the live-stock traffic has not much increased is probably due to the fact that the export of mutton has curtailed the increase of flocks.

The net revenue has slightly increased. The gross revenue is lower than in the previous year. It is £50,000 below that of four years ago; this is mainly due to the




THE CREUSOT AUTOMATIC HAMMER.

numerous and large reductions which have been made in rates and charges during the past five years, the effect of which in reducing the revenue has doubtless been generally anticipated. It is to be borne in mind that the changes have nearly all been in favor of local products, so that producers have been benefited.

The total revenue for the year was £994,843; the working expenses £687,328 (69 per cent.) and the net earnings £307,515. These roads thus earned $2,750 gross and $850 net per mile.

The chief items of freight carried were 84,147 tons wool; 158,024 tons timber; 358,021 tons grain; 700,140 tons minerals; 42,067 horses and cattle, and 907,443 sheep.

The Railway Department now performs the duties of 135 public post and telegraph offices. It also deals with the goods traffic and collects the revenues of 13 ports, in addition to the purely railway work.

During the year 11 carriages and 92 trucks have been added to the rolling-stock. The practice of manufacturing all this work in the colony, except the channel-irons and steel tires, has been followed during the past eight years, and in that time more than £100,000 worth of new work in trucks and carriages has been turned out of the

Government shops of a kind which had previously been imported.

A casualty occurred through a train being blown over during a northwest gale near the foot of the Rimutaka. Fortunately no one was injured. I have taken special precautions, since my return to New Zealand, to adopt, on this section, carriages permanently counterweighted below to prevent the recurrence of such an accident. A protective wind-fence has also been erected at the most exposed portion of this line.

| | Locomotives. | Carriages. | Wagons. | Water-services. | Stations. | Private Sidings. |
|---|---|---|---|---|---|---|
| 1880–81 ..... | 197 | 474 | 5,805 | 155 | 467 | 174 |
| 1887–88 ..... ..... | 271 | 511 | 8,153 | 274 | 664 | 251 |

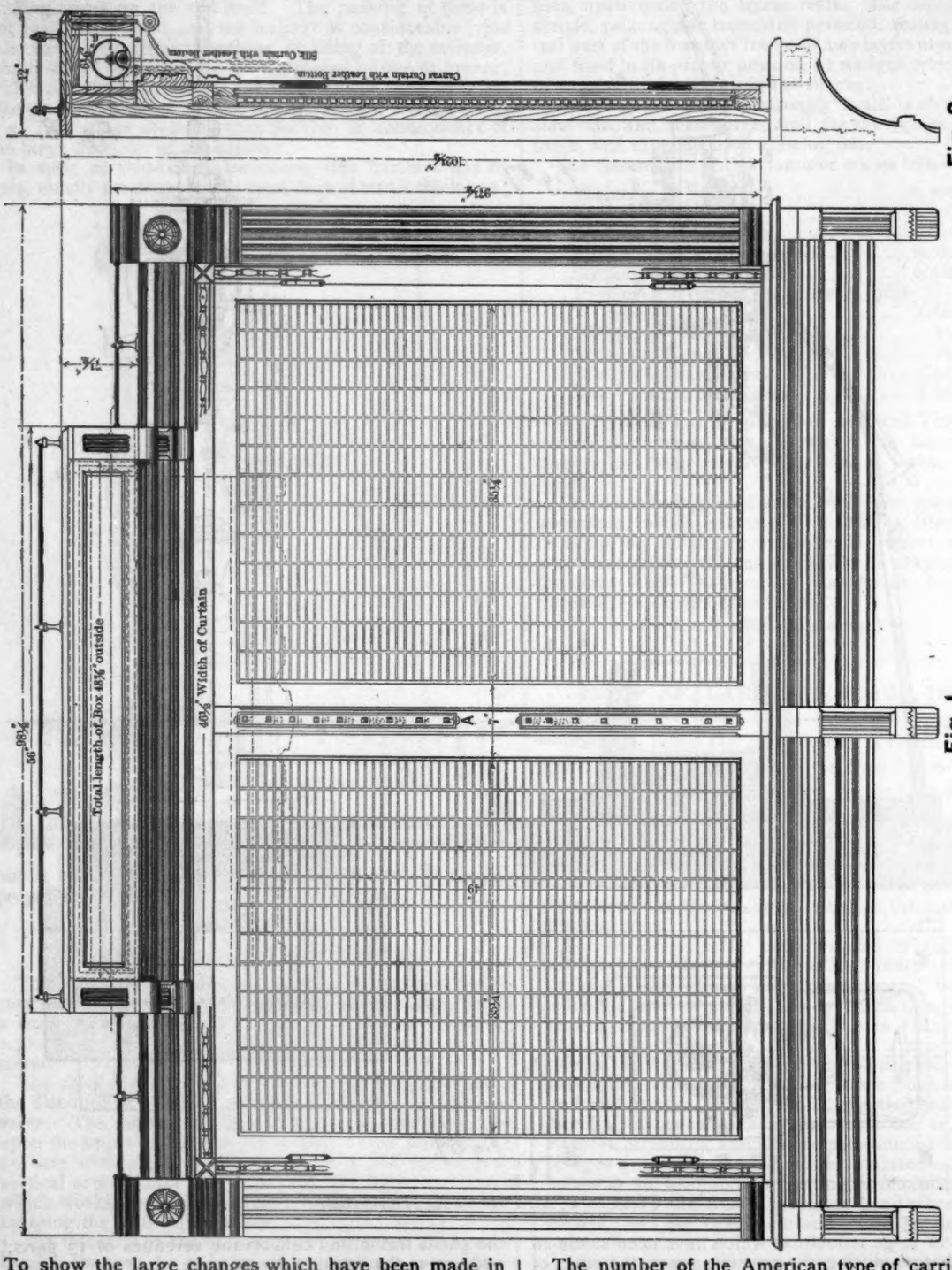



Fig. 2

Fig. 1

EQUIPMENT REGISTER CASE.

To show the large changes which have been made in the railways during the past eight years, and the increased responsibility of maintenance and general administration entailed by the additional stations, rolling-stock, appliances, and public accommodation, as well as by the greater length of the railways, and the large growth of traffic which has taken place, the following table is attached :

The number of the American type of carriages on the lines in 1880 was only 10. We have now 198 such carriages, which have been converted or built as new carriages in the colony during the interval. The comfort of the traveling public has been very materially improved thereby.

The manufacture of 10 locomotives in the colony by Messrs. Scott Brothers has been completed ; the engines

have run their test mileage, and are now in use, and are showing fair results.

After a careful trial, extending over a long period, of Winter's block-instruments, which had been supplied to us by the inventor, as adopted on the Madras railways, it was determined to substitute this system for the one previously in use here, as it gives a more complete safeguard against accident in working. During the past year the system has been introduced, and is working well.

The hydraulic cranes at Greymouth erected for the purpose of loading coal into steamers have been completed, and await the finishing of some filling and sidings to be started at work. This is the first introduction into this colony of the important system of hydraulic-crane-working on a large scale. The purpose of the cranes is to do the loading with the minimum of damage to the coal. Six-ton coal-boxes will be lifted from the trucks, lowered in the hold of the steamer, and emptied through a bottom door in the box, giving the coal a very small drop. It is possible that a system of hydraulic cranes would be of great advantage in the grain-sheds at Lyttelton and other places. Hydraulic-crane-working in England has been much extended of late years, and during my visit there, I was enabled to study its application. Our climate, being free from severe frost, is well adapted to the working of such plant.

## EQUIPMENT REGISTER AND CASE.

THE accompanying illustrations show a very convenient and well-designed register for locomotives and cars, their service and condition, which has been devised by Mr. S. H. Harrington, Chief Draftsman, and which has been put in use in the offices of the Superintendent and Assistant Superintendent of Motive Power of the New York, Lake Erie & Western Railroad at Buffalo and Cleveland. For compactness and simplicity it seems superior to anything of the kind which has yet come under our notice. The cuts represent the arrangement for the locomotive register, that for cars being only slightly different, as explained below.

Fig. 1 is a front view and fig. 2 a section of the register case, which is made to stand in the office; fig. 3 shows on a larger scale the construction of the case and the size of the pigeon-holes; fig. 4 shows, also on a larger scale, the schedule case, which is attached to the register case in

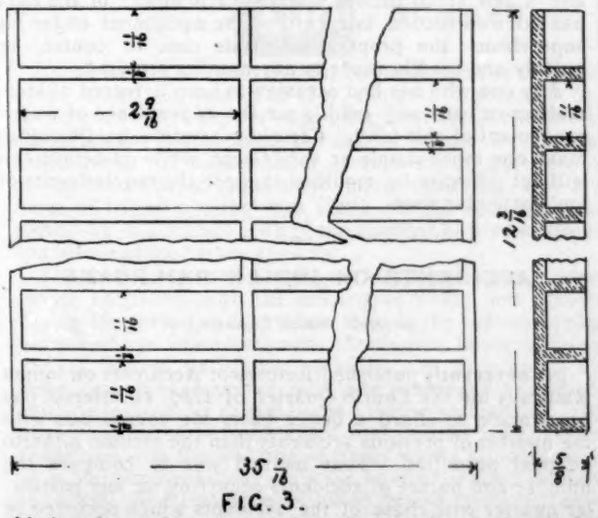



FIG. 3.

this instance; fig. 5 is an enlarged view of a portion of the case showing the register in position (the blocks in this case being shown in black and white, instead of white and black, as they are in reality); fig. 6 shows on an enlarged scale a portion of the key-frame attached to the center of the register case, as indicated in fig. 1; fig. 7 is one of the large blocks for division names, shown also in fig. 5; and fig. 8 shows the faces of the register blocks, of full size, with the classification letters and service marks for engines.

All locomotive registers heretofore made have been complicated and difficult to keep on account of the multiplicity of parts required to give full information. In the present instance, however, they have been brought down to four separate pieces. The register case, it will be seen, has a number of pigeon-holes sufficient to provide one for each locomotive; in each of these pigeon-holes are placed four cubes made of hard rubber and measuring ⅞ in. on each side. These blocks were made by the Goodrich Hard Rubber Company, of Akron, O., at a cost of $3 per hundred, so that the expense of starting the register is not excessive.

As already noted, there are four blocks in use for each engine, the first carrying simply the engine number; the

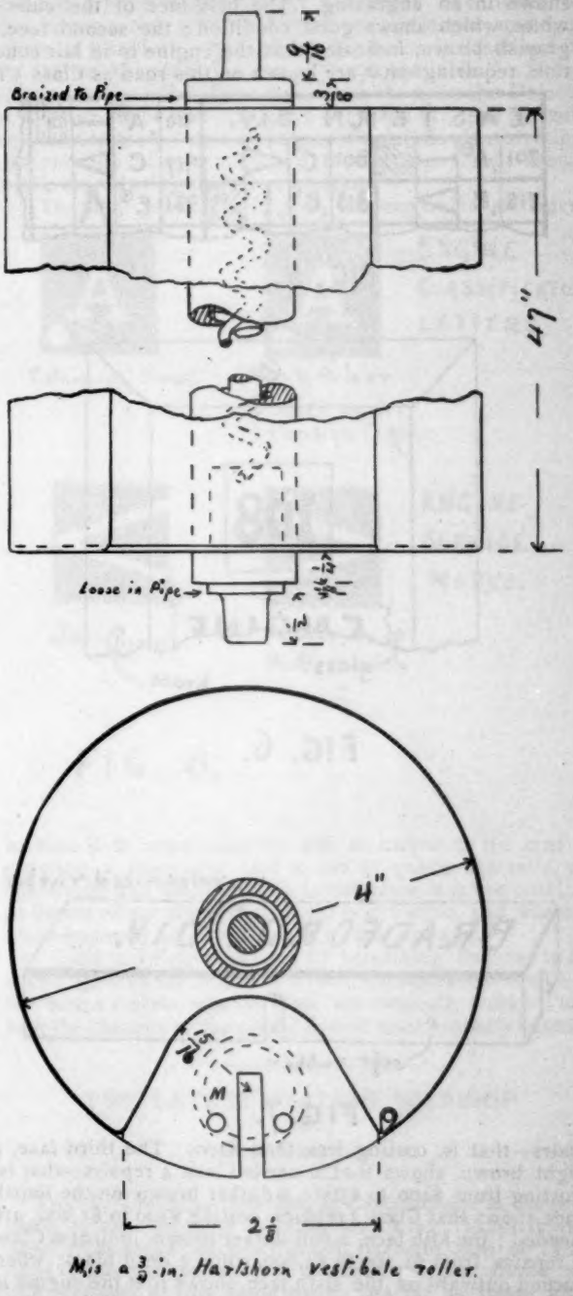



FIG. 4.

second one carries the classification letters *A*, *B*, *C*, *D*, etc., which, of course, may be varied to suit the requirements of each road. In addition to these classification letters there are placed on the blocks marks, as indicated in fig. 8, one, for instance, showing whether the engine is provided with air-brakes, another whether it has driver-brakes, another of these with extension fronts, and so on. As in the case of the letters, this may be, of course, varied to suit the requirements of any road.

The third block in order shows the service in which the engine is employed, whether passenger, freight, working, switching, pushing, or so on, and these marks may all be placed on different sides of the same block, so that if an engine is transferred from one kind of service to another all that will be necessary will be to turn out a different face of the block. One face should be left blank, so that when an engine is out of service and in the shop for repairs this blank face may be turned outward, and the fact that it is not at work may be seen at once.

The fourth block shows the condition of the engine. This is indicated by colors, and therefore can hardly be shown in an engraving. The first face of the cube is white, which shows good condition; the second face, a grayish brown, indicates that the engine is in fair condition, requiring what are known on this road as Class 5 re-

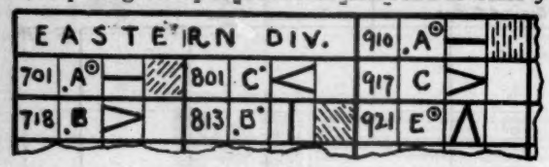



FIG. 5.

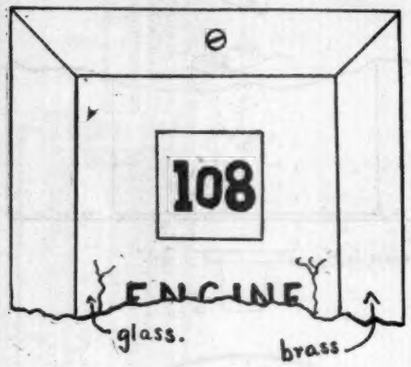



FIG. 6.

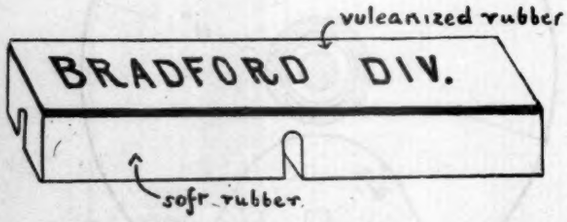



FIG. 7.

pairs—that is, costing less than $100. The third face, a light brown, shows that it needs Class 4 repairs—that is, costing from $400 to $500; a darker brown on the fourth face shows that Class 3 repairs, costing $500 to $1,200, are needed; the fifth face, a still darker brown, indicates Class 2 repairs, from $1,200 to $4,000, while a dead black, when turned outward on the sixth face, shows that the engine is in the shop getting Class 1 repairs, which will amount to over $4,000. These colors and classes can, of course, be arranged or altered as desired. Any change required by the daily reports can be made in a moment by simply taking out the block and replacing it with the proper face turned out.

A reference key, placed in the center panel of the register in a brass frame, with glass front, contains an explanation of all the blocks, and in its prominent place can be referred to at any moment by those using the register.

It will be seen that with a register of this kind properly kept the condition and service of any engine upon the road, and the division on which it is employed, can be seen at a glance, and the Superintendent can tell at once what engines are available for use, which of them are in the shop, etc. The additional information, which may be needed for reference, but which is not usually so often required—such as the general dimensions of the engine, the weight of drivers, heating surface, etc.—is kept in a book of blue-prints, 3 in. wide by 10 in. long, which has a diagram properly filled out for each class of engines. This book is kept in the pocket of the register below the doors, where it is readily accessible.

The roller or case attached to the register above, the construction of which is fully shown by the drawing, carries the schedule or time-table and performance sheets, which can be drawn down as required for reference, or can be rolled up out of the way when not needed, leaving the face of the register itself clear. All the schedules and performance sheets ordinarily required can be carried on this roller. The index or indicator on its face shows the order in which they are placed. While a very convenient addition, however, this is not a necessary part of the register, which can be made with or without it, as will readily be seen.

A register for cars can be made in exactly the same way, and one is in use on the same road. In the car register, however, the compartments can be made smaller, as only three cubes will be needed, showing number, class, and condition as to repairs. The service mark used in the locomotive case will not be needed, as passenger equipment has but one service. Here, as in the locomotive register, a fuller description of the cars can be kept in a book of blue-prints, in the pocket or drawer of the case.

In practice each Division Master Mechanic sends a weekly report to the Superintendent of Motive Power; in the office of the latter, where the engine register is kept, the proper corrections are made as the reports are received, and a duplicate of the register is made. Blue-prints of this are sent to the Vice-President, the General Superintendent, and to the Division Superintendents and Master Mechanics. These blue-prints are simply reproductions of the face of the register, showing the blocks in position, so that the engines on each division, with their condition, service, etc., can be seen at a glance, as well as by consulting the register itself. In this way, by the use of one engine register in the central office, with a blue-print chart and a few small rubber stamps, each officer of the road has full information in regard to the equipment under his supervision; the proper blue-prints can, of course, be quickly and readily made to any number required.

Any one who has had occasion to keep a record of locomotives or cars will readily see the convenience of an arrangement of this kind. Certainly it would be difficult to make one more simple or easily kept, while its details can without difficulty be modified to meet the requirements of any particular road.

## ACCIDENTS ON INDIAN RAILROADS.

(From the *Indian Engineer*.)

IN the recently published Returns of Accidents on Indian Railways for the Fourth Quarter of 1887, an attempt has been made to afford a better basis for comparison with the number of previous accidents than the method hitherto adopted permitted. That method was to compare the number and nature of accidents occurring in any particular quarter with those of the accidents which occurred in the corresponding quarter of the previous year. The Returns before us contain a comparison of the number of accidents occurring in the last quarter of 1887, with the average number in the corresponding quarters of *five* previous years, which shows the present state of affairs very much more satisfactorily than was possible with the former procedure.

Compared thus with the average of five previous quarters, the number of accidents to trains, rolling stock, permanent-way, etc., during the last quarter of 1887, shows a decrease of 64, or 10.21 per cent., against an increase of

2,534¾ miles or 22.29 per cent., in the mean mileage open, and an increase of 1,370,805 miles, or 13.18 per cent., in the train mileage.

The more important fluctuations are noticeable upon the Rajputana-Malwa; Northwestern; Eastern Bengal; South Indian; Great Indian Peninsula, and Dibru-Sadiya railways, a marked decrease being apparent in every case, with the exception of the South Indian and the Dibru-Sadiya Lines.

In the number of casualties resulting from accidents to trains, etc., the quarter under review compares favorably with the Returns of the corresponding periods of five previous years. During the last quarter of 1887, three passengers and servants were killed, and eight injured, as against averages of four and nineteen, respectively, in corresponding periods of five previous years. The high averages observed in the latter case, are due to three collisions, which took place on the Eastern Section of the Eastern Bengal, the Sind, Punjab & Delhi, and the Southern Mahratta railways, on October 2 and 18, 1884, and November 16, 1886, by which 14, 12, and 8 passengers, respectively, were injured.

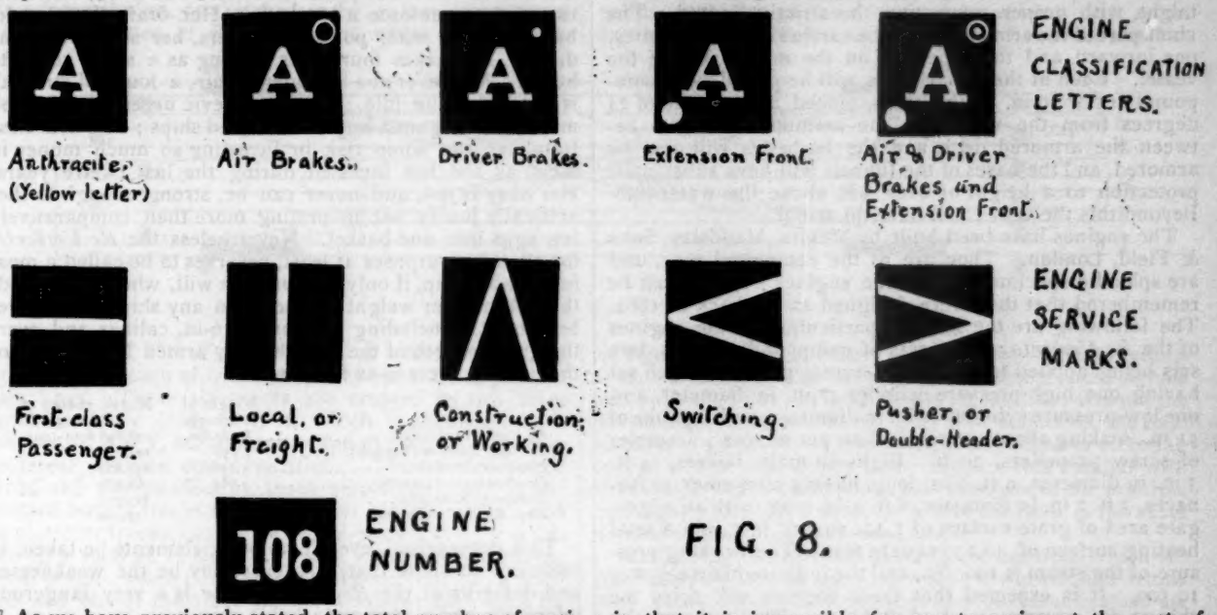



FIG. 8.

As we have previously stated, the total number of accidents, in the last quarter of 1887, shows a decrease of 64, as compared with the corresponding quarters of five previous years, the figures being 563 and 627 for the two periods, respectively. A considerable portion of the decrease is due to the reduced number of cattle accidents, only 177 cases of trains running into cattle on the line being reported, as against 205; while the number of fires in trains has been reduced from 43 to 23.

The total number of passengers killed and injured, from causes connected with the working of trains, was greater during the period under review, than in the corresponding periods of five previous years, the figures being 15 killed and 27 injured, as against 10 killed and 36 injured. Of these casualties, however, only one passenger was killed, and one injured, by causes beyond their own control. The total number of persons killed and injured from causes connected with the working of trains shows an increase of 25 in the number killed, while the number injured remains the same. The total number killed during the corresponding quarter of five previous years was 88, of which number the increase of 25 constitutes a percentage of nearly 30, while the total train mileage was only increased from 10,401,557 to 11,772,362, or 13.18 per cent.

The Government of India, in their Resolution upon the Returns under review, observe with satisfaction that, with a large increase of open mileage and train mileage, there has been a considerable reduction in the percentage of accidents, as compared with corresponding quarters in the five preceding years.

A novel feature in the Return under review is a tabulated statement by which the accidents during the year 1886 are compared with those which occurred in England in the same year, which shows that the number of minor accidents is greater in India, but the casualties in India compare favorably with the results under this head from English working. Taking each 1,000,000 train miles run, the total number of accidents of all classes upon Indian railways amounts to 59.53, while the figure for the United Kingdom is only 6.91. It is gratifying to turn from this apparent reflection upon Indian railway working to the number of casualties, which we find to be for the year in question, 9 killed and 85 injured in India, against 12 killed and 696 injured in the United Kingdom. We notice in this comparative statement that the passenger mileage, which is stated as 3,894,076,609 for India, is described in the United Kingdom column as "not available." Those of our readers who followed our remarks upon the Defects of English Railway Statistics in our issue of April 25, will not be surprised at this omission, which affords a striking confirmation of a remark we then made, which seems worth reproducing in this connection:

"The main defect in English railway traffic statistics, is that it is impossible for one to arrive at the cost of carrying a passenger and a ton of goods one mile, respectively, and without such information it is not possible to detect where the management is defective, and whether more business is being done at a cheaper rate.

"Until a different system of furnishing Returns is insisted upon by the Board of Trade, outsiders are unable to see how a railway can be most economically worked, and how the charges to the public can be most properly based."

## THE LATEST ITALIAN WARSHIP.

(From the London *Engineer*.)

THE *Re Umberto*, launched at Castellamare in the presence of the Emperor William and King Humbert, is a steel twin-screw, deck-protected, barbette ship of 13,298 tons displacement, nearly as large as the *Italia* and the *Lepanto* of the same navy. As far as beam alone is concerned she is bigger than either of those leviathans; and in this respect there is nothing that can rival her. Her dimensions are: Length, 400 ft. 4 in.; breadth, 76 ft. 9 in.; and her mean draft of water with all her weights on board is expected to be 28 ft. 8 in. She has no side armor at the water-line. A large amount of protection is, however, afforded to her by the construction of her bottom and sides, by the sub-division of her hull into a great number of water-tight compartments, and by a curved steel deck near the water-line. The ship's bottom is composed of

three skins, which form two water-tight spaces that are further sub-divided transversely. Experiments to test this mode of construction were made several years ago in Spezzia Harbor. A caisson, built up in a similar way, was moored, and a charge of 75 lbs. of gun-cotton was exploded in contact with it, and at a suitable depth. The two outer skins were ruptured, but the inner skin remained intact. Subsequently the inner one of the two spaces was filled with coal, and the experiment was repeated. This time only the outer skin was shattered. It may therefore be taken as proved that the construction of the *Re Umberto* affords protection against a considerable torpedo charge. The armored deck leaves the ship's side 6 ft. below the water-line, and curves upward until, along the middle line of the ship, it is but 2 ft. below the water-line. It is formed by a ⅝-in. steel plate, overlaid by a 2⅝-in. compound plate. Below this deck, and between it and the ship's bottom, there are over 50 water-tight compartments. Between the armored deck and the deck immediately above it there are 100 other water-tight compartments. If, therefore, water were to enter the ship either above or below the protective deck, its volume and evil effects might, with proper precaution, be strictly limited. The chief part of the armament will be carried in two barbettes, one forward and the other aft, on the middle line of the vessel. Each of these barbettes will be plated with compound armor 19 in. in thickness, placed at an angle of 24 degrees from the vertical. The ammunition hoists between the armored deck and the barbettes will also be armored, and the bases of the funnels will have substantial protection to a height of over 3 ft. above the water-line. Beyond this the vessel will have no armor.

The engines have been built by Messrs. Maudslay, Sons & Field, London. They are of the compound type, and are splendid specimens of marine engines; but it must be remembered that they were designed as far back as 1884. The following are the leading particulars of the engines of the *Re Umberto*: Four sets of compound engines, two sets being applied to work each screw propeller, each set having one high-pressure cylinder 47 in. in diameter, and one low-pressure cylinder 89 in. in diameter, with a stroke of 51 in., making about 100 revolutions per minute; diameter of screw propellers, 20 ft. Eighteen main boilers, 14 ft. 3 in. in diameter, 9 ft. 6 in. long, having altogether 72 furnaces, 3 ft. 2 in. in diameter, 6 ft. 4 in. long, with an aggregate area of grate surface of 1,444 square feet, and a total heating surface of 40,230 square feet. The working pressure of the steam is 100 lbs., and the indicated horse-power 19,500. It is expected that these engines will drive the ship at an extreme speed of 18 knots. The coal capacity of the vessel is 1,200 tons.

The armament of the *Re Umberto*, in addition to a ram, will comprise four 17-in. new model 104-ton Armstrong breech-loaders, two being mounted in each barbette; 12 6.1-in. Armstrong 4½-ton breech-loaders, carried in the batteries; six 3-in. guns and 10 machine and quick-firing guns, together with torpedoes. The so-called 104-ton gun —that is not its exact weight—has a total length of 40 ft. 9 in., the length of the rifled bore being 28 ft. 10⅝ in., and of the powder chamber 7 ft. 6 in. The number of grooves in the rifling is 80, and they have a twist of one in 50 calibers, or, in other words, of one revolution in 70 ft. 10 in. The full firing charge for the armor-piercing projectile is 900 lbs. of progressive Fossano powder; for common shell it is 600 lbs. The projectiles weigh 2,000 lbs. each. The bursting charge of the armor-piercing projectile is 32 lbs.; of the common shell, 60 lbs., and of the shrapnel, 5 lbs. The muzzle velocity of the gun, when fired with the full charge, is 199 ft. per second. The muzzle energy is 55,030 foot-tons—sufficient to raise the *Re Umberto*, guns and all, more than 4 ft. out of the water; and the projectile, at the muzzle of the gun, is capable of perforating 33⅓ in. of wrought iron. These heavy guns will be carried at a height of 28 ft. above the surface of the water.

The *Re Umberto* is to be completed for sea in 1892. Her design, which is also that of her sister ships, the *Sicilia* and the *Sardegna*, and of her kindred, the *Italia* and the *Lepanto*, has excited much criticism; and many competent judges have not hesitated to express an opinion that in the line of battle a vessel of this description would be dangerously out of place. Yet, if the *Re Umberto* is not useful as a battle-ship, it is hard to see what she can be useful for. The *Times* says that, writing in the August number of the *Jahrbücher für die Deutsche Armée und Marine*, Herr Spiridion Gopcevic denies her utility altogether. She is, he declares, neither a battle-ship nor a cruiser. She is not a battle ship for the reason that her sides are entirely unarmored. She is not a cruiser for the reason that she does not carry sufficient coal. She is, moreover, too costly to be risked on cruisers' work. For the cost of a single *Italie* or *Re Umberto*, four ironclads, each of about 3,500 tons, might, he thinks, be built. Their united strength in artillery might equal that of the big ship; and if that were so, they would, he maintains, be together much more than a match for the monster. There would be four vessels—that is, four rams against one; and it is hard to believe that, even if she were successful in one or two cases, the large vessel would put out of action or sink all her opponents before being herself sunk. Nay, more, the single ship, in this comparison, labors under the considerable disadvantages of being unable to divide herself and to be in four places at once. She is the less able, therefore, to enforce a blockade. Her draft of water debars her from many ports and waters, her size from many docks. She takes four times as long as a small vessel to build. Whenever she is under repair, a fourfold strength is doomed to lie idle. Herr Gopcevic urges all this, and much more, against huge unarmored ships; and doubtless Italy has run some risk in investing so much money in them as she has invested during the last twelve years. Her navy is not, and never can be, strong enough to theoretically justify her in putting more than comparatively few eggs into one basket. Nevertheless the *Re Umberto*, for offensive purposes at least, deserves to be called a most formidable ship, if only because she will, when completed, throw a heavier weight of shot than any ship that has yet been built. Including all guns of 6-in. caliber and over, the gun-strength of the most heavily armed battle-ships of the naval powers is as follows:

| | Weight of Discharge. | Muzzle energy of Discharge. |
|---|---|---|
| *Re Umberto* (Italian) | 8,960 lbs. | 236,896 foot-tons. |
| *Amiral Baudin* (French) | 5,950 " | 124,770 " " |
| *Victoria* (British) | 5,176 " | 132,832 " " |
| *Deutschland* (German) | 3,864 " | 66,530 " " |
| *Tchesme* (Russian) | 4,988 " | 123,772 " " |
| *Krp. Rudolf* (Austrian) | 3,000 " | 57,000 " " |

This comparison, even if no other elements be taken, is sufficient to show that, whatever may be the weaknesses and demerits of the *Re Umberto*, she is a very dangerous adversary and a very remarkable ship.

## RAILROAD SIGNALS IN EUROPE.

In a recent number the *Revue General des Chemins de Fer* gives an interesting account of the progress and changes made during the last few years in the signal apparatus in use on French and other European railroads. This article, which is by M. Gossman, Engineer of the Northern Railroad, and which is fully illustrated, has been translated for our columns, and is given in part below:

### I.—THE SAXBY & FARMER INTERLOCKING SYSTEM.

Every study of the application of an interlocking system to a station or yard rests upon this principle, that to each movement which can be made within the radius of action of a signal-station, there should correspond the change of the signal authorizing this movement. Thus, whether a locomotive passes along the main track or whether it goes upon a siding, this movement must await the opening of a signal, which can only be changed when all the apparatus on its line of passage occupies the proper position, the switches turned in the right direction and locked, and everything so arranged that the movement of the locomotive or train cannot be interfered with.

It follows from this that when, for a certain movement, it is necessary to open any given number, say *n*, of switches successively, there will be required, in order to display the

proper signal, as many distinct levers as there are switches plus 1, and the interlocking being necessarily different in each case, we would have to move, in order to open this signal, as many levers as there are directions to be taken —that is, $n + 1$.

Thus, at an ordinary junction of two tracks, the signal commanding the main track has always two levers, one corresponding to the right-hand, the other to the left-hand track, interlocked with the switch and its lock, in such a way as to secure the passage of the trains to the right or to the left, as may be desired.

In stations, and particularly in the case of a signal governing backing and shifting, the number of these levers increases rapidly, and it is not rare to find eight and 10 required for a single signal. As, moreover, the number of signals must be equal to that of the directions from which trains or engines can be moved, it will be readily seen that the number of levers becomes sometimes very great, although there may be really only a comparatively small number of switches or signals worked from a signal-station.

Thus, if we take as an example the case of the entrance into a large station, as sketched in fig. 1, into which three double-track lines, *A B C*, enter, and which has six platform tracks, *E F G H I J*, on each of which trains may enter, or from each of which they may leave for any of the main lines. These six tracks are crossed by two main switches, *M N O P*, each of which is furnished with switches, *T T T T*, at the intersection of each track, giving the freest possible communication. The inward-bound tracks are commanded by three stop-signals, *a b c*, the outward-bound tracks by three other signals, *a' b' c'*, and the platform tracks each by a signal shown at *e f g h i k*, making a total of 12 signals. Now, as each one of these would permit, when it is changed, the direction of a train upon any one of the other tracks, it follows that each inward-bound signal must be provided with six levers, and each outward-bound signal with three, making a total of 54 levers for the signals alone, without counting those which command the eight cross-junctions, *T T T T*, the four switches, *M N O P*, and the switch-locks with which they are provided. At such a signal-station we would very soon pass the point where 100 levers would be required—that is to say, we must have a very large cabin, and as the signalmen would have much ground to pass over, and many movements to make, their number would be very much greater than if the arrangements were simplified and the cabin made smaller.

To express this in a general way, for a signal-station which commands the tracks, from $m$ directions communicating with $n$ tracks or siding, the number of levers to be placed in the cabin for the stop-signals only would be $2\ m\ n$, and when the signalman must, for a movement, which may be frequently required, change successively the last inward-bound and the first outward-bound signal, he would have to pass over in a hurry, besides the space occupied by his switch levers, a space equal to $2\ m\ n \times 0.13$ meter—that is, if we take the example shown in fig. 1, a total movement of 7 meters, which would necessarily occupy considerable time.

It is true that an attempt has been made to obviate this inconvenience by grouping together the levers which are most frequently used, thus violating the usual rule, which consists in placing in the signal-cabin the inward-bound signals at the left, the switches and switch-locks in the center, and the outward-bound signals at the right hand. Now, besides the objection that the arrangement mentioned above can only be adopted when the service is fairly uniform, it also presents the inconvenience of complicating very much the apparatus, since the same signal may have its levers placed at different extremities of the signal-cabin, and in that case the attachments of the wires or chains would cause an almost inextricable entanglement.

It therefore becomes necessary to secure elsewhere a solution to the question, and Messrs. Saxby & Farmer have found it in the use of what they call "selected levers," which permits them to simplify and to reduce largely the work required in fitting up a signal-cabin.

In principle a selected lever does not work any apparatus directly; it is simply intended to make a choice or selection of the direction to be given to a movement. It is therefore interlocked with the levers of all the apparatus which effect this movement in such a way that, in order to reverse the selected lever, it is necessary first to place in proper position all the signals and all the switches which permit the movement in question; that being done, and the selected lever reversed, the single lever opening the signal authorizing the starting of the train can be moved.

From this it results that the number of selected levers will be only that of the directions in which a train or an engine can be moved. As, on the other hand, the number of signals remains as before equal to that of the directions from which a train can be moved, and each of these signals has only one lever; as finally we must take into account the movements which can be made in both directions, the total number of signal levers, including the selected or directing levers, will be $2\ (m + n)$; if we compare this number with that which would be required in a case where the multiple levers were used, it will be seen that the ratio is the same as that of a number to its logarithm.

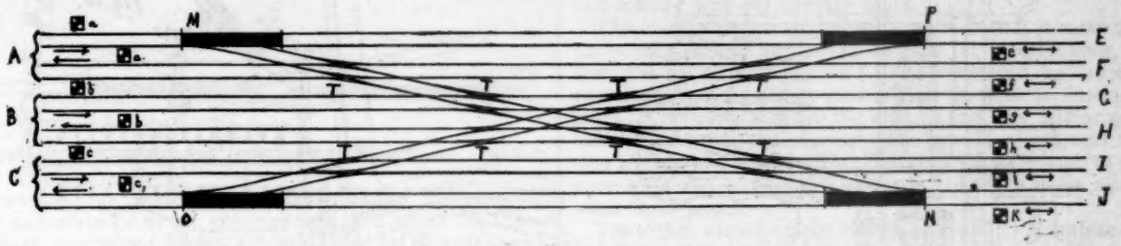



Fig. 1.

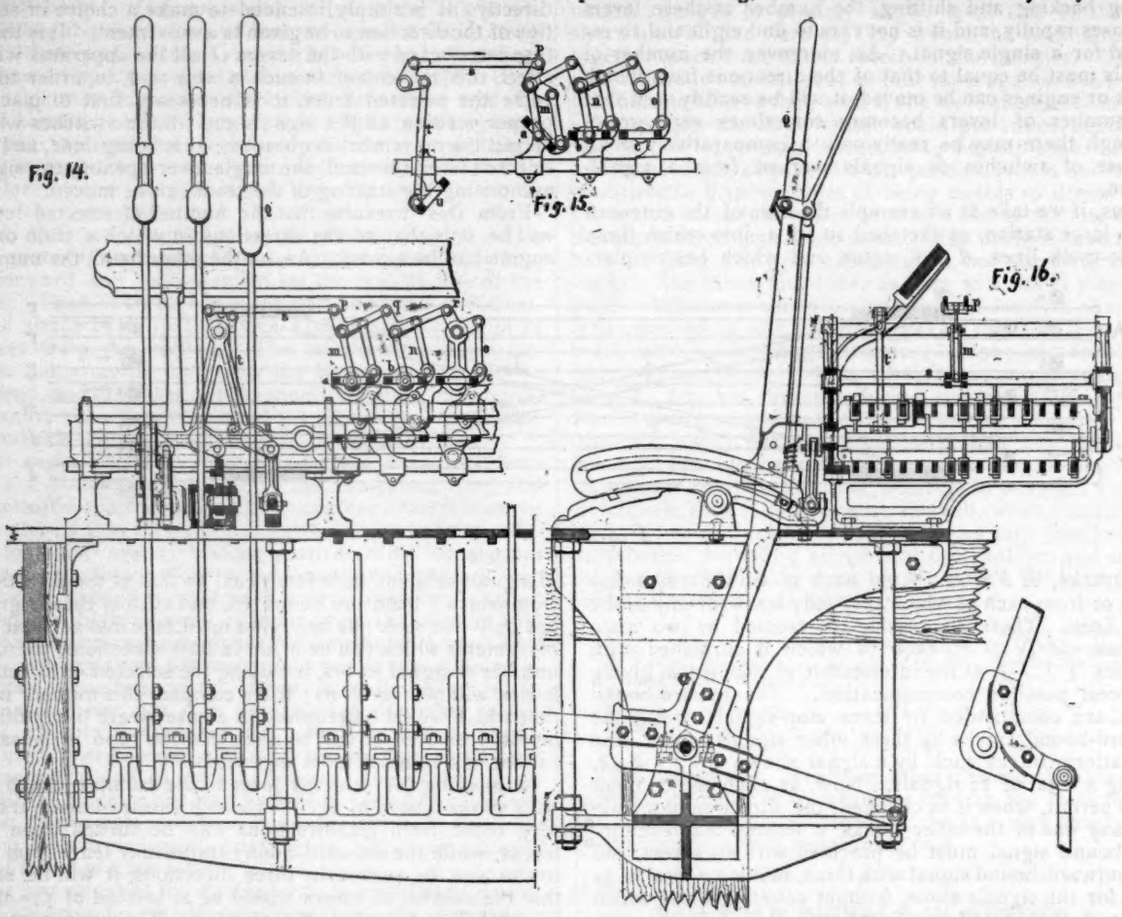
In applying the selected lever to the example which we have shown above in fig. 1, in which inward-bound trains may come from six directions and be turned upon six tracks, while the outward-bound trains may leave from six tracks and be turned in three directions, it will be seen that the number of levers would be 21 instead of 54—that is, much less than half the number. The movement required from the signalman would be only 2.70 meters; the loss of time and the amount of work would be diminished in the same proportion, and one signalman would be able to do the work which would otherwise require two.

It may be asked, and with reason, if the mental effort required from the signalman is not greater with selected levers than with the ordinary multiple levers. This question would be difficult to answer, partly because it is not easy for us to put ourselves in the place of a signalman, and partly because we cannot recall an example of a cabin in which the selected-lever system has replaced the old system, so that no account can be obtained from signalmen themselves. However, there is no doubt that if each movement is, as it were, simplified or materialized by a single lever, that idea can be more easily comprehended by a signalman than the thought that the lever is different according to the direction in which a movement is to be made. The only objection which a signalman could present is that there is one more lever to be changed with each movement; but to this it may be answered that the slight additional movement of the arms is compensated for by a great saving in the movement of the legs, and by the fact that it requires less effort of brain.

The introduction of the selected-lever system has therefore the effect of diminishing the cost, not in full proportion to the number of levers, but nevertheless in considerable degree, since the signal-cabin can be made smaller;

and also of decreasing the cost of maintenance, since the force of signalmen can be reduced and their time economized.

This combination, moreover, does not require any arrangement of apparatus which has not already been made for other purposes in the Saxby & Farmer signal-cabins; it requires only some additional interlockings, corresponding to a known formula, which, if we wish to generalize, can be solved by reference to the disposition designed and applied by M. Dujour on the Paris, Lyons & Mediterranean system. It will be sufficient to take a single example to show this.




In fig. 2 we have a track *M*, commanded by the signal 1, giving access to three tracks, *A B C*, according to the position of the switches 2 and 3, furnished with the locks 4 and 5. Let *a b c* represent the three selected levers, each corresponding to the arrival of a train on one of the tracks *A B C*. Suppose that we wish a train to enter on the track *B*, to reverse the selected lever *b* it will be necessary to prepare the track, change the position of the switch 2, to fasten the locks 4 and 5, and be sure of the position

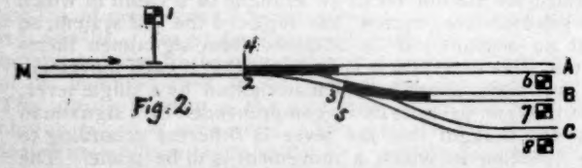


Fig. 2.

of switch 3. All these necessities are realized by the interlockings $2N : bN$, $4N : bN$, $5N : bN$, $bN : 3N$, and finally to move the lever of the signal 1, $bN : 1N$. Inversely, suppose that we wish to move a train from the track *B* out upon the track *M*; there is only one selected lever for the three stop-signals 6, 7, 8 governing the passage out of the tracks *A B C*. The interlockings which govern this movement are as follows: $2N : mN$, $mR : 3N$, $mN$ : 6, 7, and $8N$. This last additional interlocking, which is easily made, if reversed disengages either one of the three levers, 6, 7, or 8, but permits only one of them to be reversed, so that it would not be possible to direct a movement out of two or three of the tracks at once.

The use of selected levers is not the only reduction which can be made in the number of levers in an interlocking cabin. Messrs. Saxby & Farmer have made arrangements which enable them to pass by the selected levers, and to replace them by interlocking combinations, which may be called "directing combinations." It is true that these new combinations have only been applied in a few cases where new levers had to be added to an existing cabin and space was lacking, but there is no reason why they should not be used for a new installation in such a way as to reduce the number of levers.

In fact, these directing levers are only used to move an interlocking-bar which fastens or frees certain levers, and their use brings us logically to the idea of suppressing the lever and keeping only the interlocking-bar. This requires for its realization only an arrangement by which a directing-bar can be moved in the proper manner.

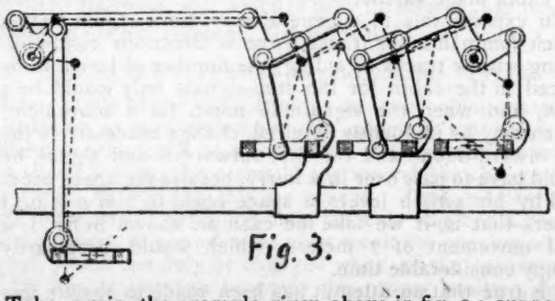


Fig. 3.

Take, again, the example given above in fig. 2; suppose a train arriving on the track *M*, which can be sent into either one of the three tracks *A B C*, and suppose there are three selected levers, *a b c*, each applicable to one of these three tracks. In place of the simple interlocking combination which we have shown above, there may be used a conditional relation of the form $aN$, $bN$, and $cN : 1N$—

that is to say, that in order to move 1 to give passage to the train, it is necessary to have first moved one or the other of the three levers *a b c*; but if instead of working a lever to change 1 we simply make possible the rotation of an auxiliary compound slotted lever, which produces the same effect, it is clear that we could avoid the use of the lever which moves this slotted lever. It would be sufficient to have three of these latter, as shown in figs. 14 and 15, each interlocked by simple connecting-rods depending from the apparatus which it is necessary to move in order to permit the entrance of the train upon the proper track. In the normal position these three slotted levers being interlocked and unable to move, the jointed parallelograms *m n o*—the right arms of which are connected by a crank with the axis of the slotted levers, while the left arms only work around that axis—cannot be changed; the points *p q r* are fixed and oppose resistance to the change of the cranks *s* and *t*, and the slotted lever *u*, with which the lever 3 is interlocked.

If, on the other hand, we move the apparatus—switches and locks—necessary to disengage the slotted lever *a*, for example, the parallelogram *m* can be changed, the point *p* can be displaced, while the lever *s* can be given a bending

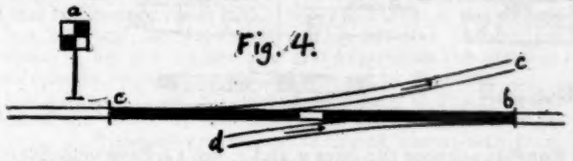


Fig. 4.

movement, the compound lever *u* is unlocked, so that the lever 2 can be reversed.

It would have been the same if instead of disengaging *a* we had moved *b* or *c*; consequently, the use of the three auxiliary compound levers *a b c* placed, so to speak, out of doors, is sufficient to give place for the directing levers and to realize the desired combination.

This arrangement has been applied in several cases, and especially at Cabin No. 2, at the Eastern Paris station. There is no doubt that, in compensation for the advantages which it presents—such as economy of space—there are inconveniences which always follow any complication in interlocking arrangements. Thus, in order to move the last slotted lever *c*, the three parallelograms shown in fig. 3 must be displaced, and from *u* to *c* there are no less than 18 axes of rotation which are brought into play, and there must result, unless the work has been very carefully done, a certain delay in the movement.

Since the time when we first described and discussed the theory of conditional interlocking, the question has been the object of much study, and we propose now to present a summary before indicating solutions applied in particular cases.

The theory of interlocking has been discussed at much length in the treatise of MM. Brame and Aguillon. Interlocking arrangements are classed by them into two groups: 1. Binary interlockings between two levers; these may be made simple, double, or special. 2. Conditional interlockings, generally between more than two levers, and almost impossible to analyze theoretically, so that we must limit ourselves to studying examples applicable to certain particular cases.

We may also mention a note published in our columns by M. Pichon some time ago on the General Solution of Ternary Interlockings, in which the Author observes with truth that most ternary interlockings are not conditional, and his conclusion is that if they are referred to a general type they can be analyzed and strictly defined.

As there is nothing to prove that a study, analogous to that which M. Pichon has undertaken in the case of three levers, will not give also a general solution for the interlocking of any number of levers, we propose to replace the erroneous term "conditional interlocking" by the term "compound interlocking," which may designate any system of more than two levers, whatever may be the form of the arrangement.

Lastly, in the second volume of their Treatise on Railroad Management, MM. Flamache and Huberti, examining the question of interlocking, complain—and not without reason—that our notation cannot conveniently be applied to all compound interlocking systems, and propose a new one, which, while it does not do away with the old, at least supplements it wherever it is not fully applicable. The signs proposed by these authors are as follows: + means and; — or; ( ) permits; *a*, lever *a* in normal position; *b'*, *b* reversed.

Let us suppose, for instance, that the lever *a* can only be reversed if *b* is in normal position, *c* reversed, and *d* reversed; then we would write it thus:

$$(b + c' + d')\, a'$$

instead of the three expressions, $bR : aN$, $cN : aN$, and $dN : aN$.

Thus in a single expression we condense the different interlockings which can affect a lever; but we must not conclude that the only relation for which the expressions cited can stand is a compound one, for the translation of each of these relations can be obtained by binary or simple interlockings.

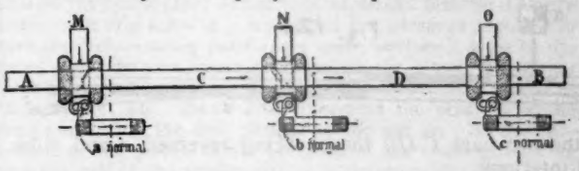
The following expression shows a compound interlocking noted on this system: $(a' - a + b)\, c$. This means that *a* normal or reversed, and *b* normal, permit *c* to be reversed.

This notation has the advantage that it can easily be used in cases of reciprocal action, and also that by it we can readily pick out similar cases.

The only criticism that can be made is that it rests upon an idea absolutely opposed to that of interlocking. In fact, the parenthesis marks ( ) are translated by the word permits or frees, which means that there is no interlocking; in our notation, on the other hand, the bar or colon has the advantage of representing graphically a real relation of interlocking, without obliging the operator to suppose that the movement is made in order to be able to write it on paper.

Thus the arrangement: "If $aN$, $bR : cN$ unless $dN$ or $eN$," which means that we can reverse *c*, 1st, if *a* is reversed; 2d, if *a*, *b*, and *d* are normal; 3d, if *a*, *b*, and *e* are normal, would be written: $(a' - a + b + d - a + b + e)\, c$.

It may be asked whether the first notation, which consists simply in writing the relation as it is presented to the mind, as it would proceed in practice—only replacing the usual words by some abbreviations—is not more simple than the other, in spite of the advantage, more apparent than real, which the last has of expressing reciprocal actions clearly and rapidly. It is possible that we may



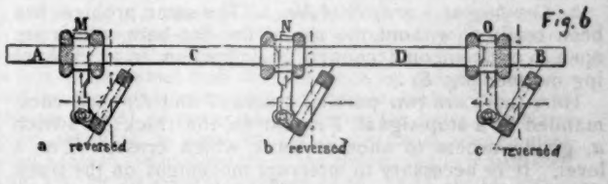



Fig. 6

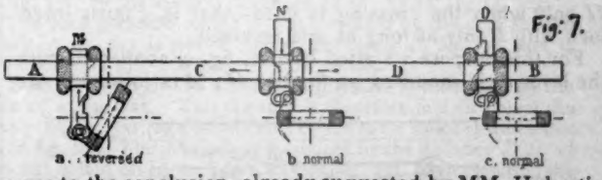


Fig. 7.

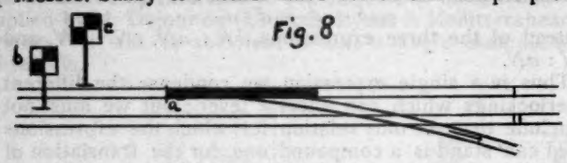
come to the conclusion, already suggested by MM. Huberti and Flamache, that it is best to use one or the other notation according to the case presented.

As examples of the application of compound interlocking systems we give below several apparatus recently installed in different yards to solve particular problems presented.

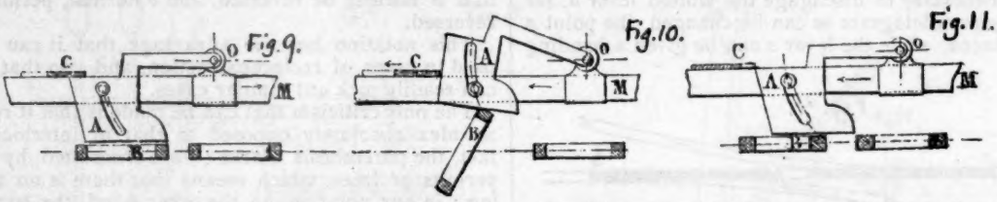
1. *St. Denis Yard, Signal Post No. 1.* The track, *c b*, fig. 4, is provided with a stop-signal *a*, which protects the point of the switch *b*, but which had to be placed before the switch *c*, because there was not room for it between the two switches. The object is to cover *b* safely without

delaying movement in the direction *c e*—that is, when *c* occupies its normal position, shown in fig. 4 by the black shading, the signal *a* can only be changed when the switch *b* is not turned toward *d*; but this interlocking relation must not continue when *c* is turned in the direction *e*. In their normal position the three apparatus are free, but if *b* is reversed, *a* becomes interlocked so long as *c* is normal, and is freed when *c* is reversed.

Messrs. Saxby & Farmer have solved this simple prob-




lem as follows : The slotted levers depend on three levers, *a b c*, fig. 5, commanding, by means of pin-joints, three vertical flat bars, *M N O*, having each an inclined slot, by which they can move the auxiliary rods *C D* in a horizontal




direction. Thus, if we pass from the normal position—fig. 5—to an intermediate position—fig. 6—by reversing the lever *a*—that is, by changing the stop-signal, we move the rod *C*, which enters the notch in the flat bar *N*, and prevents its descent in such a way that the slotted lever *B* is locked, and that the position of the switch *b* can only be changed while *c* remains in its normal position ; but, as soon as *c* is reversed, play is given to the rod *D*, which was held between the narrow parts of the two flat bars, and nothing opposes the descent of the bar *N*, which takes only a slight displacement toward the right, when we reverse the slotted lever *b*—fig. 7—set free.

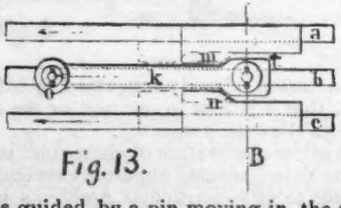
It will readily be seen that, reciprocally, if—fig. 5—we begin by opening the switch *b*, *a* will be interlocked as long as *c* is normal, and the flat bar *M* can only descend and free the slotted lever *a* when we move *c* to give play

to the two bars *C D*; then, *c* being reversed, *a* and *b* do not interlock.

2. *Compiegne Yard, Post No.* 1. The same problem has been realized, without the use of the flat bars, which are open to criticism on account of their friction, in the following manner (fig. 8) :

Here there are two parallel tracks, *I* and *II*, each commanded by a stop-signal, *b c*, and on the track *I* a switch *a*, giving access to another track, which crosses *II* on a level. It is necessary to interrupt movement on the track *II* only when the crossing is used—that is, *c* must interlock with *b* only as long as *a* is reversed.

For this purpose a slotted bar, *A*, fig. 9, connected with the lever *a*, is mounted on the bar *M*; *A* is jointed to the




axis *O* and is guided by a pin moving in the slot, and has thus at once a movement of oscillation around *O* and a movement of translation given to it by the bar *M* moving horizontally. In the normal position shown in fig. 9 we can change both *b* and *c*, fig. 8, the slotted lever *B* being able to turn, and the plate *C* able to move within the limits shown by the dotted lines, without interfering with the movement of *A*; reciprocally, if those signals are changed, *A* bearing against the plate *C* prevents the movement of the rod *M*, and locks the lever of the switch *a*.

Lastly, if *c* is reversed and we change the position of the switch *a*, the plate *C* prevents the motion of *A*, and consequently the slotted lever *B* cannot be moved, and the signal *b* is then locked.

3. *Turcoing Yard, Post No.* 1. This is an example of a balanced interlocking arrangement, which solves the problem of an alternative combination in a different way.

In fig. 12 we have a stop-signal normally withdrawn, placed in advance of a cross-over switch *b*, beyond which is a switch *c*, furnished with a lock, the normal position of which is drawn back. It is necessary to lock the switch *c* only when a train runs over the cross-over *b* to go upon the track *c d*; as the lock has only a single hole, corresponding to the right of the switch, it is sufficient to make *a* interlock with the lock *a c*, but only when *b* is opened.

For this purpose the bars *a* and *c*, fig. 13, have shoulders *m* and *n*, and the bar *b* has a connecting-rod *k* jointed at the point *O* and furnished with a square head *t* having its side-faces beveled. In the normal position shown in fig. 13 the bar *b* can only move when *a* or *c* has been moved back so as to bring the shoulders *m* or *n* into the position shown by the dotted lines. The connecting-rod is then moved to one side or the other by the beveled face moving on the inclined shoulder *m* or *n*, and the bar *b* is unlocked. The signal for the cross-over can thus be given only after the lock is thrown—that is, after the switch *c* is opened ; otherwise the signal *a* must be set at stop, which would forbid the movement.

(TO BE CONTINUED.)

## Blast Furnaces of the United States.

THE *American Manufacturer* gives its usual monthly table of the condition of the blast furnaces on November 1, and says : "The totals are as follows :

| | In Blast. | | Out of Blast. | |
|---|---|---|---|---|
| Fuel. | No. | Weekly capacity. | No. | Weekly capacity. |
| Charcoal | 75 | 14,005 | 93 | 10,594 |
| Anthracite | 97 | 28,442 | 99 | 25,692 |
| Bituminous | 141 | 88,273 | 86 | 41,713 |
| Total | 313 | 130,720 | 278 | 77,999 |

"Our table shows that the number of furnaces in blast was 313, compared with 310 on October 1—an increase of 3. The charcoal furnaces show an increase of 2, and the bituminous 3, but the anthracite show a decrease of 2, making the net increase 3. The weekly capacity of the furnaces in blast was 130,720 tons, compared with 129,710 tons on October 1. This shows a net increase of 1,010 tons—charcoal, increase, 1,022 tons ; anthracite, decrease, 1,144 tons ; bituminous, increase, 1,132 tons.

"The appended table shows the number of furnaces in blast November 1, 1888, and on November 1, 1887, with their weekly capacity :

| | Nov. 1, 1888. | | Nov. 1, 1887. | |
|---|---|---|---|---|
| Fuel. | No. | Weekly capacity. | No. | Weekly capacity. |
| Charcoal | 75 | 14,005 | 80 | 14,145 |
| Anthracite | 97 | 28,442 | 125 | 36,720 |
| Bituminous | 141 | 88,273 | 148 | 94,982 |
| Total | 313 | 130,720 | 353 | 145,847 |

"This table shows that the number of furnaces in blast was 40 less than at the same date in 1887, the decrease being distributed as follows : Charcoal, 5 ; anthracite, 28 ; bituminous, 6. The weekly capacity of the furnaces blowing was 130,720 tons ; at the corresponding date last year, 145,847—decrease, 15,127 tons."

## CATECHISM OF THE LOCOMOTIVE.

*(Revised and enlarged.)*

By M. N. Forney.

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*(Continued from page 518.)*

### CHAPTER XIX.

### ACTION OF THE PISTONS, CRANKS, AND DRIVING-WHEELS.

QUESTION 524. *Is the whole of the net effective pressure which is exerted on the pistons communicated to the crank-pin?*

*Answer.* No, a part of this pressure is exerted to overcome the inertia of the pistons and other reciprocating parts during the first half of the stroke, while the back pressure resists their movement and helps to stop them at the end of the stroke.

QUESTION 525. *How can we show the pressure which is exerted on the crank-pin?*

*Answer.* By first constructing a diagram similar to fig. 88, to show the pressure for any given speed which must be exerted on the piston during the first half of the stroke to accelerate it, and that which must resist it to bring it to a state of rest during the last half, and then laying off the net effective pressure, as indicated in fig. 243, on the line that represents the pressure which must be imparted to and is given out by the piston.

Thus a line, *E F*, fig. 331, should be drawn to represent the length of the stroke on the same scale as that used for *H D*, fig. 243. *E F* may also represent the line of atmospheric pressure. From the extremity *E* a perpendicular, *E N*, should then be drawn below *E F*, and another, *F L*, from *F* above *E F*. The centrifugal force of the reciprocating parts should now be calculated. With the same data and calculations given in Question 160 and its answer, we will have a centrifugal force of 14,660 lbs., which must be exerted at the beginning of the stroke to accelerate the piston. The influence of a connecting-rod seven times the length of the crank will increase this force one-seventh, as explained in answer to Question 165, so that it will be equal to

$$14{,}660 + 2{,}094 = 16{,}754 \text{ lbs.}$$

At the end of the stroke the force which will be exerted by the momentum of the reciprocating parts will be

$$14{,}660 - 2{,}094 = 12{,}566 \text{ lbs.}$$

If, now, we divide these forces by the area of the piston (which is 17 in. diameter) =227 square inches, and it will give 73.8 and

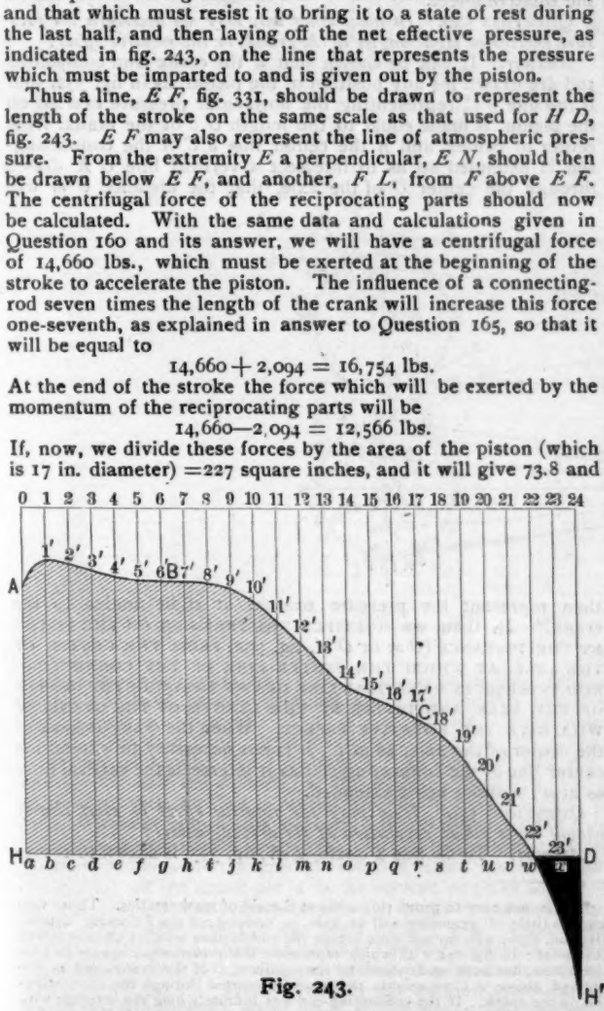



Fig. 243.

55.3 lbs. as the pressure per square inch which must be exerted at the beginning and end of the stroke to start and stop the piston. A distance, *E H* = 73.8, should then be laid off on the perpendicular *E N* below the atmospheric line *E F*, and a distance, *F D* = 55.3 lbs., above the atmospheric line. The point at which there is neither acceleration nor retardation of the piston is where the center lines of the crank and of the connecting-rod are at right angles. This is the case where the piston is still one inch ahead of the middle of its stroke, or has moved 11 in. If, now, we mark this point *g* on the atmospheric line *E F*, and draw the arc of a circle, *H g D*,* through the three points which have been laid down, the vertical distance of this line below *E F* will indicate the pressure per square inch at each point of the stroke which must be exerted on the piston at the speed named to accelerate it, and the distance of *g D* above *E F*, the pressure required to retard the piston. In other words, the vertical distances of *H g* below the atmospheric line *E F* represents the pressure on the piston which is needed to move the reciprocating parts alone during the first part of the stroke, and the vertical distance of *g D* above *E F* shows the pressure which they will exert on the crank-pin during the last half of the stroke, or the force which must be exerted to bring them to a state of rest. If we take the vertical distances *H A*, *b* 1′, *c* 2′, *d* 3′, etc., from

* This curve is not exactly an arc of a circle, but such an arc is a sufficiently close approximation to the actual curve for the present purpose.

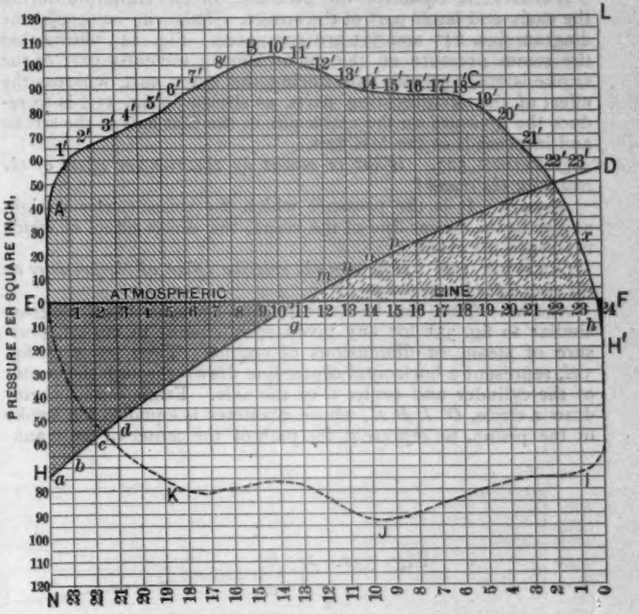



Fig. 331.

fig. 243—which represent the net pressure on the piston—and lay them off on the vertical lines above and from the curved line *H g D*, fig. 331, and draw a curve, *A B C x*, through their extremities, then the vertical distance of this curve above the atmospheric line *E F* will represent the net effective pressure which is exerted on the crank-pin. It has been explained that the distance of the curve *H g below E g* represents the pressure required to move the reciprocating parts *alone*, and therefore it must be deducted from the total steam pressure on the piston to get that which is exerted on the crank-pin. Consequently the distances 1 1′, 2 2′, 3 3′, etc., above *E D* represent the pressure on the crank-pin during the first portion of the stroke. As the momentum of the piston exerts pressure on the crank-pin during the latter half of the stroke—which is represented by the vertical distance of *g D* above *g F*—therefore the steam pressure on the piston must be *added* to this momentum and the pressure represented by the distances *m* 12′, *n* 13′, *o* 14′, etc., of fig. 243, are laid off above and from the curve *g D*, fig. 331, and are indicated by the same letters and numbers in both figures. The pressure exerted on the crank-pin during the latter part of the stroke, therefore, is equal to that of the steam acting on the piston *added* to the momentum of the piston, and is represented in fig. 331, by the vertical distances 12 12′, 13 13′, 14 14′, etc.

The back pressure on the piston indicated by the area shaded black in fig. 243 is laid off below the line *g D*, fig. 331, and is *deducted* from the momentum of the piston.

Thus, at 23 in. of the stroke this pressure is measured by the line 23′ *x*, fig. 243. This distance is therefore laid off below the line *g D*, fig. 331, and is indicated by the same number and letter as in fig. 243. The pressure represented by the distance *D H′* of fig. 243 is laid off in the same way on fig. 331. By extending the curve *A B C f* through *x* and *H′*, its distance above the line *E F* will therefore represent the pressure on the crank-pin during the whole of the backward stroke, and its distance below *g F* the back pressure exerted on the pin.

The length *a A*, *b* 1′, *c* 2′, etc., of the vertical lines in the shaded area *H E A B C f* represent the steam pressure in pounds per square inch on the piston. Their length *a o*, *b* 1, *c* 2, etc., in the area *H E g* represents in the same way the portion of the pressure which must be exerted on the piston to move and accelerate the reciprocating parts from the beginning to the middle of the stroke. The area *g D F* represents the horizontal pressure exerted by the reciprocating parts during the last half

of the stroke. The area *D f H* shows the net back pressure on the piston near the end of its stroke, *g f h* the net effective pressure exerted by the momentum of the reciprocating parts during the last half of the stroke, and the area *E A B C f F*, above the horizontal line *E F*, shows the net effective horizontal pressure exerted on the crank-pin. A similar diagram has been made for the forward stroke of the piston, but has been laid off *below* the lines *E g F* and *H g D*, and is represented by the dotted line *H' I J K E*.

QUESTION 526. *In what way does the momentum of the reciprocating parts modify the effect of the pressure of the steam when it is worked expansively?*

*Answer.* It equalizes the pressure on the crank-pin during the early and latter part of the stroke. This will be seen if the diagram figs. 243 and 331 are compared. Fig. 243 shows that the steam pressure on the piston during the early part of the stroke is much greater than during the latter part, whereas the effect of the reciprocating parts, as shown in fig. 331, is to reduce the pressure on the crank-pin in the first half of the stroke and increase it in the last half.

QUESTION 527. *What is meant by the rotative effect of the steam on the crank?*

*Answer.* It is the pressure which the steam exerts at right angles to the center line of the crank, the direct effect of which is to turn the crank.

QUESTION 528. *How can the rotative effect of the pressure on the crank-pin be ascertained?*

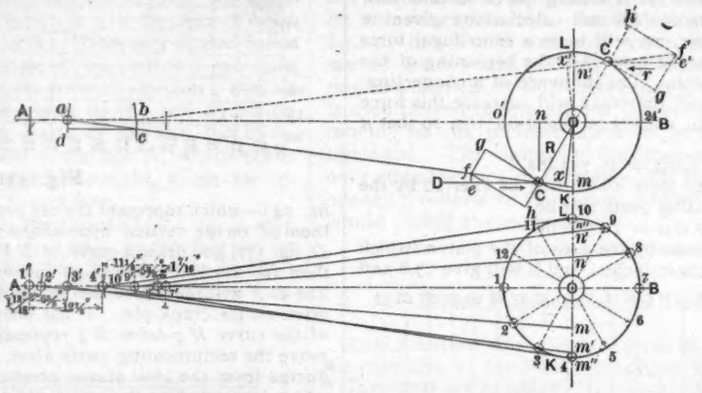
*Answer.* This can be done by first constructing a diagram similar to fig. 331 for any given speed, point of cut-off, pressure of steam, or dimensions of engine. Then let *A B*, fig. 332, represent a horizontal center line drawn through the center of the cylinder and center *O* of the axle. From *O* as a center draw a circle, *O' L B K*, whose diameter is equal to the stroke of the piston, to represent the path of the center of the crank-pin. From the front dead-point *O'*, with a distance equal to the connecting-rod, lay off the mark *A* on *A B*, which will be the position of the center of the cross-head pin at the beginning of the stroke. Now, for any position of the crank-pin, such as *C* as a center, and with the length of the connecting-rod as a radius, describe a short arc *a*, intersecting the line *A B*. Then the distance *A a* will be equal to the movement of the cross-head pin, which is equal to that of the piston from the beginning of the stroke. Then draw *a C* to represent the center line of the connecting-rod when the piston has moved the distance *A a*. From *a* a distance, *a b*, should be laid off equal to the horizontal pressure, in pounds per square inch, exerted by the combined action of the steam pressure and momentum of the reciprocating parts. Now, if this pressure is exerted against the end of the connecting-rod *a C*, which at this point of the stroke is inclined to the center line *A B*, its inclination will cause an upward vertical pressure to be exerted at *a*, which must be resisted by the guides. If, then, *A b* is drawn equal to the horizontal force, and *b c* parallel to the vertical line *a d*, and if from the intersection *c* of *b c* with *a C* a line, *d c*, is drawn parallel to *a b*, we will have a parallelogram, *a b c d*, of which the center line *a c* of the connecting-rod forms a diagonal, and the side *a b* is equal to the horizontal force, *b c* will be equal to the vertical pressure, and *a c* will represent the pressure exerted in the direction of the center line of the connecting-rod.

To ascertain the pressure exerted on the crank-pin, it is a little more convenient to draw a horizontal line, *C D*, through the center of the crank-pin and parallel with *A B*. Then from *C* lay off *C e*, equal to the horizontal pressure, and draw the vertical line *e f*, then *f C* will be the pressure exerted by the connecting-rod in the direction *a C* of its center line. To determine the pressure that is exerted in the direction *g C* at right angles to the crank *C O*, the force *f C* may be resolved into two components, one acting in the direction *g C* at right angles to the crank, and the other in the direction of *C O* of its center line. If we extend *C O* to *h*, and from *f* the end of *f C*, we draw *f g* parallel to *O h*, the center line of the crank, and from the center *C* draw *C g* at right angles to *C O*, and complete the parallelogram *f g C h*, then we have a parallelogram of which the diagonal represents the magnitude and direction of the force acting through the connecting-rod, and the sides are parallel to the direction into which we want to resolve this force. Therefore *g C* represents the force exerted by *f C* at right angles to the crank, and *h C* that in the direction of its center line.

If the crank is in the position shown by the dotted lines at *C'*, and the pressure of the connecting-rod is exerted on the crank-pin in the direction of the arrow *r*, then the rotative effect can be ascertained in a similar way to that already described—the horizontal line *C e'*, equal to the horizontal pressure, is drawn through the center of the crank-pin, and the center line *b C* of the connecting-rod is extended to *f'*. A perpendicular *e' f'* is then drawn from *f'* through *e'*, and *C' f'* is equal to the pressure of the connecting-rod on the crank-pin. A line *C' g'* is drawn perpendicular to the center line *C' O* of the crank, and through *C* and *f'* lines *C h'* and *f' g'* are drawn parallel to the crank, and from *f' f' h'* is drawn parallel to *C' g'*. We then have the parallelogram *C' h' f' g'*, of which *C' g'* or *h' f'* represents the rotative effect.

QUESTION 529. *In what other way may we ascertain the pressure exerted at right angles to the crank, or the rotative effect?*

*Answer.* It can be shown that if the crank and connecting rod are drawn for any position of the piston, as in fig. 332, that if the line *e C*, representing the horizontal pressure exerted on the piston, is made equal to the length *O C* of the crank, from center to center, and if the center line *a C* of the connecting-rod is extended so as to intersect a vertical line *O K* drawn through the center *O* of the axle, that the distance *O m* will




then represent the pressure exerted at right angles to the crank.* If, then, we MULTIPLY THE PRESSURE ON THE PISTON BY THE DISTANCE (*O m* or *O n'*, fig. 332) FROM THE CENTER OF THE AXLE, AT WHICH THE CENTER LINE OF THE CONNECTING-ROD INTERSECTS A VERTICAL LINE DRAWN THROUGH THE CENTER OF THE AXLE, AND DIVIDE BY THE LENGTH OF THE CRANK, IT WILL GIVE THE ROTATIVE EFFECT. When the crank is back of the center of the axle, as at *C'*, it is not necessary to extend the center line of the connecting-rod as it intersects the vertical line, as at *n'*, without being extended.

QUESTION 530. *How may the rotative effect be most clearly shown for a whole revolution of the driving-wheel?*

*Answer.* To do this a circle, *L K*, fig. 333, is drawn to repre-

* It is not easy to prove this without the aid of mathematics. Those who know a little of geometry will be able to understand the following demonstration, those who do not must accept the conclusions without understanding the proof: In fig. 332, *e C*, which represents the pressure per square inch on the piston, has been made equal to the radius *C O* of the crank, and as explained above *f C* represents the pressure exerted through the connecting-rod on the crank. If the connecting-rod was infinitely long the leverage with which it would act on the crank would be equal to the vertical distance *C n* of the center of the crank-pin, from the line *A B*, and the rotative effect would be equal to the pressure on the piston multiplied by *C n*. But owing to the angularity of the connecting-rod, the leverage through which it acts on the crank is equal to *O x*, a line drawn through the center *O* of the axle and perpendicular to *a C m*. So that the rotative effect is equal to the pressure *f C* exerted through the connecting-rod, multiplied by *O x*. As the two triangles *C f e* and *O x m* are similar,

$$O x : O m :: C e : C f,$$

so that $O m \times C e = O x \times C f$.

As *C e*, which represents the horizontal pressure of the piston and reciprocating parts, has been made equal to *C O* or *R*, the radius of the crank, we have

$$O m \times R = O x \times C f,$$

that is, the horizontal pressure of the piston and reciprocating parts multiplied by *O m* is equal to the rotative effect. A similar demonstration will prove that $O n' \times R$ will be equal to the rotative effect when the crank-pin is in the position *C'*.

sent the path of the center of the crank-pin, and a horizontal center line *A B*, as described. Now divide the circle into 12 equal divisions—1, 2, 3, 4, etc. From the dead-points 1 and 7, with the length of the connecting rod as a radius, mark 1′ and 6′ on *A B*; these will represent the two ends of the piston's stroke. Now from 2 as a center, and with the length of the connecting-rod, intersect *A B* at 2′ with a short arc, and draw 2′ 2 *m*. Then 1′ 2′ will represent the distance that the piston has moved while the crank has turned from 1 to 2, or one-twelfth of its revolution. In a similar way 3 3′, 7 7′, 8 8′, 9 9′, can be laid down, which will give us the movement of the piston for successive twelfths of the stroke during the first and third quarters of a revolution. To avoid confusion in the diagram the position of the connecting-rod has not been laid out for the second and fourth quarters of the revolution, and also because the positions of the crank-pin and piston are the same during the first and fourth and the second and third quarters of the revolution.

horizontal lines below *C D* are supposed each to represent 10 lbs. pressure per square inch, as indicated by the figures on the left hand side of fig. 334, and the pressure which has been calculated can be laid off from 2‴ to *E*. Proceeding in the same way for the third position, 3 3′, of the crank, we find that the piston has moved 6⅞ in., as shown in fig. 333, and *O m*′ is equal to 11⅛ in.

Therefore, $$\frac{140 \times 11\frac{1}{8}}{12} = 129.8.$$

This pressure is laid off from the line *C D* on the perpendicular 3‴ *F*. In the same way the rotative effect is calculated and laid down in fig. 334 for each of the successive positions, 4, 5, 6, 7, etc., of the crank, shown in fig. 333, and curves *C E F G H I J* and *J K L M N P D*, fig. 334, are drawn through the points laid down on the perpendicular lines. The vertical distance of these curves below *C D* then represents the rotative effect which is exerted at each point during a complete revolution of the driving-wheel.

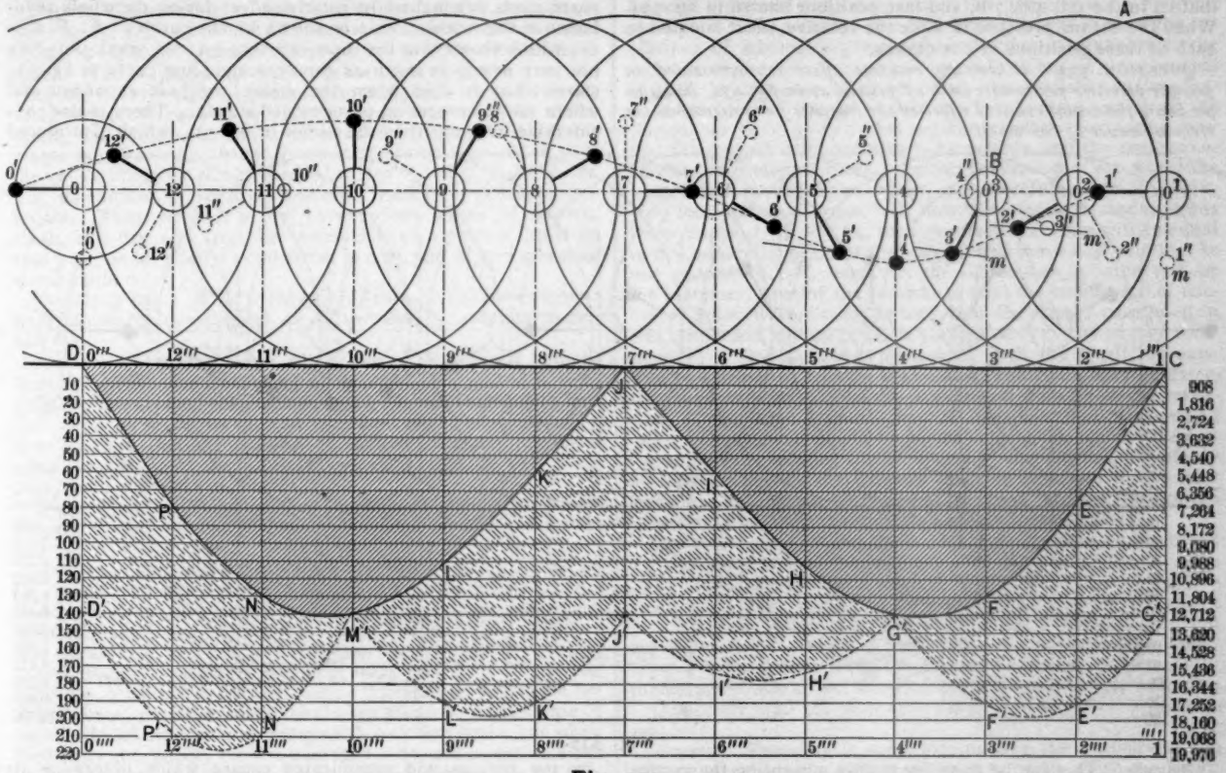



Fig. 334.

Next draw a horizontal line, *C D*, fig. 334, equal in length to the circumference of the driving-wheel, and subdivide this line into twelve equal divisions—1″ 2″ 3″ 4″ 5″ 6″, etc. From these points of division draw perpendiculars 1″ 1, 2″ 2, 3″ 3, etc. Draw the horizontal line 1 0 above *C D* so that 1 1″ and 0 0″ are equal to half the diameter of the wheel. Then from 1 as a center and with 1 1″ as a radius, describe a circle, *A B C*, to represent the driving-wheel, and from 1 lay off the crank-pin 1′ in the first position shown in fig. 333. As this is the dead-point the pressure of the piston exerts no rotative effect on the crank. From 2 lay off the crank-pin 2′ in the second position shown in fig. 333. As *C D* has been made equal in length to the circumference of the wheel, and it has been divided into twelve equal parts, 1‴ 2‴ is equal to one-twelfth of the circumference, so that the wheel *A B C* in turning one-twelfth of a revolution would roll from 1‴ to 2‴. From 2 as a center we then draw another circle to represent the wheel when it has turned one-twelfth of a turn and has rolled from 1 to 2. The crank is then in the position shown at 2′ in fig. 333, and the piston has moved 1⅛ in. By drawing 2′ *m* to represent the connecting-rod, we find that *O m* is equal to 6¾ in. It will be supposed now that the engine is running at a speed of only four miles an hour, and that there is a uniform pressure of 140 lbs. on the piston, as shown by the diagram fig. 237. At this slow speed the power required to accelerate and retard the reciprocating parts is so little that it may be disregarded.

To get the rotative effect for the position of the crank shown at 2 2′, fig. 335, we must then multiply 140 × 6¾ = 945, and divide by 12, which gives 78.7 as the rotative effect *in pounds pressure per square inch of the piston*. The spaces between the

But while the pressure on the piston on one side of the locomotive is acting on its crank, there is a simultaneous action on the other crank which stands at right angles to the first one, and whose successive positions is shown by the dotted lines 1 1″, 2 2″ 3 3″, etc. The rotative effect acting on the wheels is therefore equal to that exerted on each of the cranks added together. To show this combined effect, then, we must lay off other curves from those already drawn. Thus, the opposite crank 1 1″ in the first position of the wheel stands at right angles to the center line 1 0, and *O m* is then equal to 12 in., so that we have $$\frac{140 \times 12}{12} = 140.$$

Therefore 140 is laid down from 1‴ to *C* on the vertical line 1‴ 1⁗. A similar calculation is made for the rotative effect of the crank 2 2″ in the second position, and it is laid off from *E* to *E*′. Proceeding in the same way for the other position of the crank, and laying off the distances *F F*′, *H H*′, etc., and drawing the curve *C*′ *E*′ *F*′ *G*′ *H*′—*D*′ through the points thus laid down, we have a curve whose distance below the line *C D* represents the combined rotative effect exerted by the pressure in the two cylinders during a whole revolution.

QUESTION 531.* *What peculiarity may be observed in the form of this curve?*

*Answer.* It will be seen that the rotative effect varies very much at different points of the revolution. It is greatest when the wheel is midway between the positions 11 and 12, when the two cranks are in front of the axle and stand at angles of 45° with horizontal or perpendicular lines. When the wheel is between the 2 and 3 and 8 and 9 positions, or when the cranks both

again stand at angles of 45° with a horizontal line, the rotative effect is equal, though somewhat less than it is when the cranks are both in front of the axle. Between the 5th and 6th positions of the wheel, when the cranks are both behind the axle and at angles of 45° to a horizontal line, the rotative effect is less than at any of the other high points.

QUESTION 532. *How may this peculiarity of the variation in the rotative effect be explained?*

*Answer.* It is due to the fact that when both cranks are in front of the axle the effect of the angularity of both connecting-rods is to increase the rotative effect. When one crank is in front and the other behind the axle, the one connecting-rod increases and the other diminishes the rotative effect, and when the two cranks are behind the axle, both rods diminish the rotative effect.

QUESTION 533. *At what points in a revolution is the least rotative effect exerted?*

*Answer.* When one of the two cranks is at a dead point, that is, in the 1st, 4th, 7th, and last positions shown in fig. 334. When the steam pressure is alike the rotative effect is equal in each of these positions of the cranks.

QUESTION 534. *When the rotative effect is represented in pounds pressure per square inch of piston, as in fig.* 334, *how can we know the actual rotative effect or the tractive force exerted at the circumference of the wheel?*

*Answer.* This can be done by simply measuring the vertical distances of the curve with a different scale. Thus, in fig. 334 the spaces between the horizontal lines below *C D* have been supposed to represent 10 lbs. pressure on each square inch of the piston, as indicated by the figures on the left-hand side. If the piston is 17 in. in diameter its area would be very nearly 227 square inches. Ten pounds' pressure would therefore exert a total pressure of 2270 lbs. on the piston. If the wheel is 5 ft. in diameter and the stroke 2 ft., the pressure on the piston would be exerted with a leverage of 2 to 5, so that the actual tractive force would be

$$\frac{2270 \times 2}{5} = 908 \text{ lbs.}$$

for each ten pounds of pressure. If, then, we suppose the spaces between the horizontal lines each represent 908 lbs., as indicated by the figures on the right-hand side, we can measure the actual tractive force exerted at the circumference of the wheel.

QUESTION 535. *How can we lay off curves to represent the rotative effect when the pressure in the cylinder is not uniform during the stroke, and when the speed is so high that the acceleration and retardation of the reciprocating parts has an important influence on the action of the engine?*

*Answer.* To do this a diagram, fig. 335, similar to fig. 334, should be laid down. For each position of the crank we must ascertain the movement of the piston. Then construct a diagram like that represented by fig. 331, and from that take the net horizontal pressure exerted on the crank when the piston is in the position indicated. Thus, when the crank is in the second position represented in figs. 333 and 335, it has turned one-twelfth of a revolution, and the crank has moved $1\frac{3}{16}$ in. From the diagram fig. 331 we find that the pressure at $1\frac{3}{16}$ in. of the stroke measured above the line *E F* is 65 lbs. As *O m* is equal to $6\frac{1}{4}$ in., we have for the calculation,

$$\frac{65 \times 6\frac{1}{4}}{12} = 36.5.$$

We therefore lay off 36.5 from 2‴ to *E*. In the third position of the crank the piston has moved $6\frac{3}{8}$ in.; the pressure is then 90 lbs., and *O m* is equal to $11\frac{1}{8}$, so that the rotative effect is equal to 83.4 lbs., which distance is laid off from 3‴ to *F*. Similar calculations are made for other positions of the crank, and the curves *C E F G—D*, and *C′ E′ F′ G—D′* are drawn in the manner described. The latter curve then represents the rotative effect when cutting off steam at one-third of the stroke and at a speed of 50 miles per hour.

QUESTION 536. *What is the effect of working steam expansively at high speeds?*

*Answer.* As already pointed out, the effect of cutting off steam early in the stroke, and the influence of the reciprocating parts, tends to equalize the rotative effect during the whole revolution of the wheel. This is shown by the curve *C′ E′ F′ G—D′*, which shows that the rotative effect on the crank-pin does not vary nearly as much as the corresponding curve in fig. 334 shows that it does when the steam was not expanded and where the reciprocating parts moved slowly. There is also considerable irregularity in the curves in fig. 335, which is produced

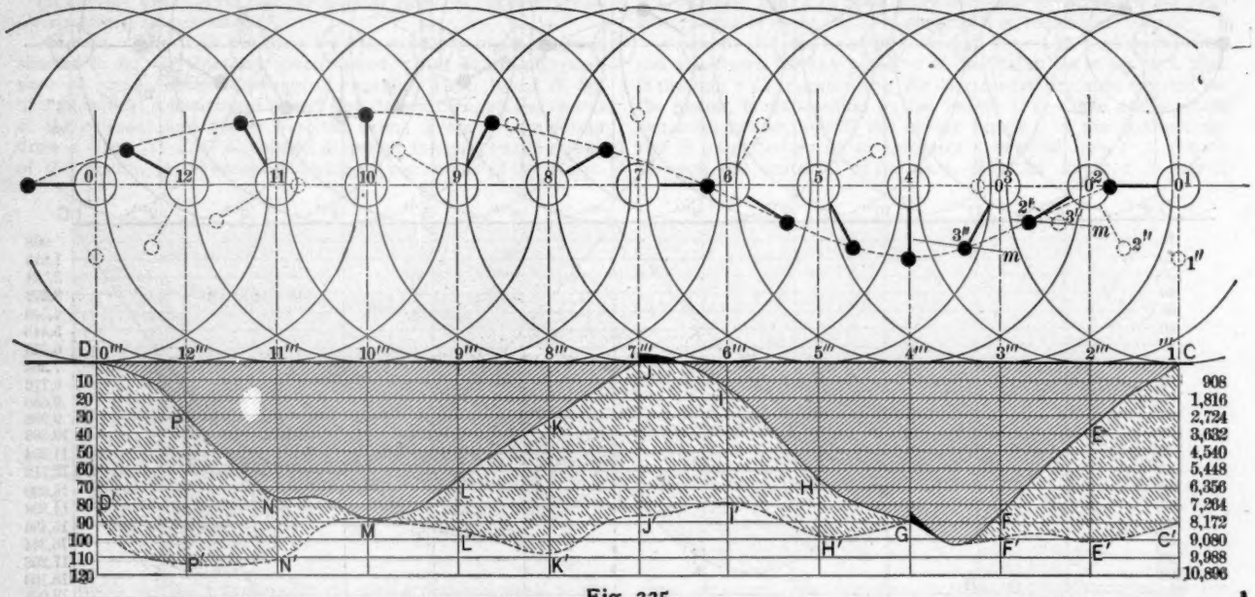



Fig. 335.

by the various and complicated causes which determine its form. The black areas at *G* and *J* represent the back pressure on the piston, shown also at *F* in fig. 331. The dotted line drawn through the centers of the crank-pin in figs. 334 and 335 show the path in which the pin moves during one revolution of the wheel.

## CHAPTER XX.

## FRICTION AND LUBRICATION.

QUESTION 537. *What is meant by friction?*

*Answer.* Friction is the resistance between two bodies in contact which opposes the sliding of the one on the other. Thus, if a brick is placed on a board with a slight inclination, it will not slide because the friction between them, or the resistance opposed to motion, is greater than the force exerted by the weight of the brick to move it downward. If, however, the inclination of the board is increased sufficiently so that a larger proportion of the weight of the brick urges it downward, then the friction will be overcome, and it will slide. When the brake-blocks of a car are pressed against the wheels, they produce friction, which resists the revolving motion of the wheels, and if the resistance of this friction is greater than the propelling force, the car will ultimately stop; and when the weight of an engine is supported on the driving-wheels and they rest on the rails, the friction between them and the rails, as has already been pointed out, resists their slipping on each other, and thus enables a locomotive to exert tractive force. Friction also resists the turning of an axle on its journal, which is overcome by the tractive power of the locomotive.

QUESTION 538. *On what does the amount of friction depend?*

*Answer.* The amount of friction of two bodies in contact depends (1) UPON THE PRESSURE OF THE ONE ON THE OTHER, AND

SO FAR AS THE FRICTION OF THE PARTS OF RAILROAD MACHINERY IS CONCERNED MAY IN PRACTICE BE REGARDED AS INDEPENDENT OF THE AREA OF THE SURFACES IN CONTACT; (2) ON THE NATURE OF THE MATERIALS IN CONTACT; (3) ON THE NATURE OF THE SUBSTANCE, SUCH AS OIL OR OTHER LUBRICANT, WHICH IS INTERPOSED BETWEEN THEM; (4) ON THE SPEED; (5) ON THE TEMPERATURE. Thus, a brick will slide down an inclined board as easily if it is laid on its broadest side as it will if placed edgewise; and if a cast iron plate, say 10 inches square, is planed and scraped, so as to be as nearly a perfect plane surface as it is possible to make it, it will, if loaded with, say, a hundred pounds' weight, slide on a similar true surface as easily as another plate with half as much area and loaded with the same weight. A shaft resting against a long bearing will require no more power to turn it than would be needed if the bearing was short.*

QUESTION 539. *What is meant by the "co-efficient of friction?"*

*Answer.* It is the proportion which the resistance to sliding motion bears to the force pressing the surfaces together. Thus, a smooth, clean, and dry cast iron plate loaded with 100 pounds will require a force of about 15 pounds, or fifteen one-hundredths of the weight or pressure of the plates, to slide them on each other. The *co-efficient of friction* is therefore said to be 0.15, and with any other weight or pressure on the plates we could determine the force required to slide them on each other by multiplying the pressure by the co-efficient of friction. Thus, if the plates were loaded with 250 pounds, the force required to slide the one on the other would be equal to $250 \times .15 = 37.5$ pounds. The co-efficient of friction, however, varies for different materials. Thus, while it is 0.15 between two pieces of smooth, clean, and dry cast iron, the co-efficient of a piece of brass on cast iron, under similar conditions, is 0.22, and of two pieces of wood about 0.4.

QUESTION 540. *What is the effect of introducing some unguent or lubricating material, such as oil, between the surfaces in contact?*

*Answer.* The co-efficient of friction is very much reduced thereby. Thus, the co-efficient of the cast iron plates, if their surfaces are greased with tallow, is 0.1; if lubricated with lard 0.07, with olive oil 0.064, and with lard and plumbago 0.055, thus showing that the amount of friction depends very much upon the nature of the lubricant which is used, as well as on that of the materials in contact.

QUESTION 541. *What effect on the amount of friction has the manner of applying the lubricating material to the surfaces in contact?*

*Answer.* The more perfect the lubrication the less will be the co-efficient of friction. It has, for example, been found by experiments made with cast iron shafts turning on bearings of the same material that when the lubricating material was applied so that the surfaces were only "unctuous," that is, slightly greasy, the co-efficient of friction was very little less than when they were dry, that is, when there was no lubricating substance between them, and that when they were greased "from time to time" the co-efficient was reduced to 0.07 and 0.08; but when they were continually oiled it averaged 0.05, and sometimes fell as low as 0.025, showing that with the best lubrication the friction was only one-sixth what it was when the surfaces were only "unctuous." Between these two limits there is every degree of frictional resistance, according to the condition of lubrication. This shows how important it is that the oiling fixtures should be kept in the most perfect condition and the utmost care be exercised in keeping every part of a locomotive thoroughly lubricated.

QUESTION 542. *What effect does the pressure per square inch of the surfaces in contact have upon the lubrication?*

*Answer.* The tendency is, when this pressure becomes excessive, to press out the lubricant which is between the two surfaces, and ordinary experience proves that the greater the weight or the force per square inch with which two bodies are pressed together, the greater is the difficulty of keeping them perfectly lubricated.

Thus it is easier to keep the journals of a car well lubricated when it is empty than when it is heavily loaded, and the guide-bars of a locomotive are more liable to be abraded when the engine is pulling a heavy load than with a light one.

QUESTION 543. *What effect has the velocity of the surfaces in contact on the friction and lubrication?*

*Answer.* With the surfaces in the same condition, the friction is nearly independent of the velocity of motion of the surfaces against each other, but perfect lubrication becomes more difficult as the velocity increases, so that an increase of velocity will often increase indirectly the amount of friction. Thus, taking our previous illustrations, it is more difficult to keep the journals of a car or engine well lubricated when running fast than when running slow, and the same thing is true of the guide-bars.

QUESTION 544. *What considerations should govern the proportions of frictional bearings for locomotives and other machines?*

*Answer.* The dimensions to be given them should not be determined from a consideration solely of their resistance to rupture,* but they should be made so large that the pressure they must bear will be distributed over so much surface that the proportion borne by each square inch will be comparatively small, thus making good lubrication much less difficult, and consequently reducing the co-efficient of friction.

QUESTION 545. *Is not the amount of energy required to overcome the friction on a journal of large diameter greater than would be required if the journal was smaller?*

*Answer.* If the co-efficient of friction in the two cases is the same, undoubtedly the large journal will require the greatest expenditure of energy to turn it, because its periphery moves further than that of the small one; but the advantage attributed to large journals is that they can be lubricated more perfectly, because their surfaces being larger the pressure is not so great per square inch, and thus the gain from the reduction of the co-efficient of friction is greater than the loss attributable to the increase of the diameter of the journal. Thus, if a car journal is $3\frac{1}{4}$ in. in diameter $\times$ $5\frac{1}{2}$ in. long, the available surface exposed to friction is equal to that of a longitudinal section of the journal, or $3\frac{1}{4} \times 5\frac{1}{2} = 17.875$ square inches.† Supposing now that the journal is loaded with 5,000 pounds, and the average co-efficient of friction is 0.085. In one revolution of the wheel the journal will move 0.85 of a foot, and therefore $5{,}000 \times .085 = 361\frac{1}{4}$ foot-pounds of work. If, now, the journal is made, as has been proposed, $3\frac{1}{4} \times 7$ in., then its effective surface will be equal to $26\frac{1}{4}$ square inches, but the journal will move 0.98 of a foot in one revolution. If, however, the lubrication is improved by the increased area of the journal so that the co-efficient of friction is reduced from 0.085 to 0.07, then the energy consumed in one revolution will be equal to $5{,}000 \times 0.07 \times .98 = 343$ foot-pounds, or less than was consumed with the small journals. The co-efficient of friction is assumed, and could only be determined by experiment, but the assumption shows how the resistance of the large journals may be less than that of the small ones. Of course it would be better to give the increased bearing surface by adding to the length of the journal, but nearly all locomotives and car journals must be increased in diameter as well as in length when they are enlarged, in order to have the requisite strength to carry the loads they must bear.

QUESTION 546. *Is the law that* FRICTION IS IN PROPORTION TO THE PRESSURE ON EACH OTHER BY THE SURFACES OF CONTACT *true under all circumstances?*

*Answer.* No; there is a limit to the exactness of the above law, when the pressure becomes so intense as to crush or grind the parts of the bodies at and near their surfaces of contact. At and beyond that limit the friction increases more rapidly than the pressure;‡ and the friction then becomes very irregular.

QUESTION 547. *In what cases is the limit referred to probably reached?*

*Answer.* Probably in some locomotives the pressure of the driving-wheels on the rails is sufficient to partly crush the latter.

QUESTION 548. *What effect has the nature of the materials in contact on the friction?*

*Answer.* The amount of friction and also the lubrication is very much influenced by the nature of the bearing surface and also by the material used as a lubricant. Some metals, such as brass and other alloys, are much less liable to abrasion, and seem to retain lubricants on their surfaces better than other metals, and are therefore much used for journal and other bearings. Some substances, especially oils, are good lubricants, while other materials of apparently similar nature are not. The reason why these materials possess these properties while others are without them is not known, and the value of any material as a lubricant, or the degree to which another will resist friction without abrasion, can only be tested by experiment.

## CHAPTER XXI.

## COMBUSTION.

QUESTION 549. *What is meant by combustion?*

*Answer.* By combustion is meant the phenomenon ordinarily called burning, as when a piece of wood or coal or a candle is burned. In reality combustion is a union of one of the "*chem-*

* Ordinarily somewhat less power is required to turn it if the bearing is long than if it is short, the reasons for which will be explained hereafter.

* Morin's Mechanics.

† The reason for this is that the effective surface of the journal which resists the pressure of the bearing, is equivalent only to the horizontal area just as the surface which resists the pressure inside of a boiler is equivalent to the diameter multiplied by its length, as was explained in answer to Question 191.

‡ Rankine.

*ical elements,*" oxygen, of which the atmosphere is composed, with the elements which constitute the fuel.

QUESTION 550. *What is meant by the term "chemical element?"*

*Answer.* The science of chemistry has demonstrated that nearly all substances by which we are surrounded are composed of certain other substances, which latter, as far as is now known, are not compounds, and are therefore called *elementary substances, or chemical elements.* Thus, the air by which we are surrounded is composed of two gases, called nitrogen and oxygen; water is composed of hydrogen and oxygen, and coal chiefly of carbon and hydrogen. There are now over sixty of these elementary substances known. From no one of them have chemists been able to extract any material excepting the substance itself. These elementary substances will combine with others so as to form what is apparently a new material, but on weighing it it will be found that the weight of the new material is greater than the original elementary substance, showing that something was added to it which effected the change.*

QUESTION 551. *To what fact is this combination or combustion of elementary substances due?*

*Answer.* It is owing to the fact—the exact reason for which is, perhaps, not yet understood fully—that the atoms of the elementary substances of which fuel is composed, that is, hydrogen and carbon, and the atoms of oxygen, which forms part of the atmosphere by which we are surrounded, attract each other with great energy when they are excited into activity by the application of heat.

QUESTION 552. *What phenomenon always attends chemical combination of substances?*

*Answer.* Such combination always gives out heat, whereas their separation absorbs heat. It has further been proved by actual experiment that the amount of heat liberated by the chemical union of the same quantity or number of atoms of two or more substances is always the same, and that when, by any cause, the atoms thus joined are separated, exactly the same amount of heat is absorbed.†

QUESTION 553. *In what proportions do the elementary substances combine with each other?*

*Answer.* It is a law of chemistry that each of the elementary substances combines with the others in certain definite proportions only. These proportions vary for the different elements, and have been determined with great accuracy by chemists. Thus, eight parts by weight of oxygen will combine with nitrogen and form atmospheric air, or the same proportion of oxygen will combine with hydrogen and form water, or with carbon and form carbonic acid, which is the deadly gas which accumulates at the bottom of wells.

Now oxygen always combines with other substances in the proportion of eight parts by weight, or by *some simple multiple of* eight, that is, $8 \times 2 = 16$ parts, or $8 \times 3 = 24$ parts, etc. Each of the other elementary substances also has a certain fixed proportion in which it combines with others, and this proportion, which is usually given by weight, is represented by a number called its *chemical equivalent.* Thus 8 is the chemical equivalent of oxygen. Carbon combines with other elements in proportions of 6 and nitrogen in proportions of 14, so that 6 and 14 are the chemical equivalents of carbon and nitrogen. Now 8 parts by weight of oxygen can be made to combine with 14 parts of nitrogen, or $8 \times 2 = 16$ parts of oxygen will combine with 14 of nitrogen, but it is impossible to make, say 12 parts of oxygen combine with 14 parts of nitrogen. We can combine $14 \times 2 = 28$ parts of nitrogen with 8 parts of oxygen, but no chemical process can make say 10 or 20 parts of nitrogen combine with 8 parts of oxygen. If 20 parts of nitrogen are mixed with 8 parts of oxygen, then the latter will combine with 14 parts of the former, but 6 parts of nitrogen will be left, and chemical combination will then cease.

The following table will give the chemical equivalents of the principal elements which enter into the process of combustion of the fuel used in locomotives:

| | Chemical equivalent by weight. |
|---|---|
| Oxygen | 8 |
| Nitrogen | 14 |
| Hydrogen | 1 |
| Carbon | 6 |
| Sulphur | 16 |

QUESTION 554. *What effect do the proportions in which elements are combined have upon the substances which are produced by the combination?*

*Answer.* A change in the proportions in which the elements are combined usually alters the entire nature of the substance, so far at least as it affects our senses. For instance, oxygen unites chemically with nitrogen in different proportions, forming five distinct substances, each essentially different from the others, thus:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 14 | parts of | Nitrogen | with | 8 | of | Oxygen | forms Nitrous Oxide. |
| 14 | " | " | " | 16 | " | " | " Nitric Oxide. |
| 14 | " | " | " | 24 | " | " | " Hyponitrous Acid. |
| 14 | " | " | " | 32 | " | " | " Nitrous Acid. |
| 14 | " | " | " | 40 | " | " | " Nitric Acid. |

We here find the elements of the air we breathe, by a mere change in the *proportions* in which they are united, forming distinct substances, which differ from each other as much as *laughing gas* (nitrous oxide) does from that most destructive agent *nitric acid*, commonly called *aqua-fortis.**

QUESTION 555. *What occurs when a fresh supply of bituminous coal is thrown on a bright fire in the fire-box of a locomotive?*

*Answer.* The fresh coal is first heated by the fire, and if a sufficient quantity is thrown in to prevent the immediate formation of flame,† a volume of gas or vapor, usually of a dark yellow or brown color, is given off. The quantity evolved will be greatest when the coal is very small. This gas or vapor is commonly called smoke, but it does not deposit soot and in reality is not true smoke. If a sheet of white paper be held over the vapor as it escapes from the coal and there is no flame, the sheet will become slowly coated with a sticky matter of brown color difficult to remove, and having a strong tarry or sulphurous smell; whereas if a sheet of paper is held over smoke it will quickly be covered with black soot. The color and smell left on the paper in the first case are due to the tarry matter, sulphur, and other ingredients in the gas. Deprived of the coloring matters, the vapor is a chemical mixture of 2 parts of hydrogen and 6 parts of carbon, and is called carburetted hydrogen, and is nearly the same as the colorless gas by which our houses are lighted.‡ A similar gas is generated at the wick of a burning candle or lamp and is consumed in the flame. Before the gas is expelled from the fresh coal the latter must be heated to a temperature of about 1,200 degrees, so that if 100 pounds at a temperature of 50 degrees is put on the fire 23,000 units of heat will be absorbed to heat the coal.§ Nor is this all, as has been explained in answer to Question 38, when any substance is vaporized a certain amount of heat apparently disappears, which has been called the *heat of evaporation* or *of gasification.* Average bituminous coal contains about 80 per cent. of carbon, 5 per cent. of hydrogen, and 15 per cent. of other substances usually regarded as impurities. When the coal is heated up to about 1,200 degrees, the 5 per cent. of hydrogen unites with three times its weight of carbon, and thus 20 per cent. of the coal is converted into the gas described. In this process a large amount of heat is absorbed or becomes latent, as it does when water or any other substance is converted into vapor. It will therefore be seen that the first effect of putting fresh coal on the fire *is to cool the fire.* This fact has an important bearing on the question of combustion and will be referred to hereafter.

(TO BE CONTINUED.)

* "The New Chemistry," by J. P. Cooke, Jr.
† *Ibid.*

* Combustion of Coal and the Prevention of Smoke, by C. Wye Williams.
† Usually if more than two or three shovels full are thrown in there will be no immediate formation of flame.
‡ A Treatise on Steam Boilers, by Robert Wilson.
§ The quantity of heat required to heat coal is only about one-fifth that needed to heat the same weight of water to the same temperature.

# Manufactures.

## Bridges.

WORK has been begun on the new bridge over the Mississippi at Memphis, Tenn. This bridge will have a cantilever channel span of 770 ft., the longest yet built in the world, and two others of 620 ft. each. It is to be 34 ft. wide and 75 ft. above high water, with accommodation for a double-track railroad and a roadway for vehicles. The west approach will have an iron trestle 5,200 ft. long and a 1,800-ft. embankment; the east approach will have a 1,000-ft. trestle. The estimated cost is $2,200,000.

THE Philadelphia Bridge Works of Cofrode & Saylor at Pottstown, Pa., are furnishing all the iron beams, roof trusses and other iron work for the new passenger station of the New Jersey Central Railroad in Jersey City.

THE National Paint Works, Williamsport, Pa., have fur-

nished paint for the Poughkeepsie Bridge, the new bridge over the Ohio at Cincinnati, and several other large structures.

THE Berlin Bridge Company, East Berlin, Conn., has a number of orders on hand for bridges and roof work.

THE new bridge over the Missouri River, between Omaha and Council Bluffs, cost $800,000, and is the property of a local company. It is, with the approaches, 4,600 ft. in length and has a 25-ft. roadway with 8-ft. sidewalk. The roadway has a single track for the motor car line. Mr. Frank D. Moore is Chief Engineer of the Company. Hopkins & Scully, of St. Louis, were the contractors for the pier and superstruction. The Edgmoor Iron Works of Wilmington, Del., superintended and supplied the iron work.

## Locomotives.

THE Grant Locomotive Works, Paterson, N. J., are building 15 locomotives for the New York, Lake Erie & Western Railroad.

THE Rogers Locomotive Works, Paterson, N. J., have a large order for locomotives for the Chicago, Rock Island & Pacific Railroad.

THE New Jersey Central Railroad is about to add to its motive power 30 consolidation engines with the Wootten fire-box.

IN the shops of H. K. Porter & Company, Pittsburgh, two locomotives for a Japanese railroad are in progress. This firm has already sent several engines to that country.

## Electric Notes.

BY an agreement made between the Westinghouse Electric Company, of Pittsburgh, and the Consolidated Electric Company, of New York, the former is placed in control of the latter company. The property of the company absorbed consists of a large manufactory on West Twenty-third Street, New York, and another in Pittsburgh. The use is given to the Westinghouse Company of all the Sawyer-Mann patents and entire capital stock of the Sawyer-Mann Electric Company.

THE Electric Automatic Transit Company, controlling the patents for sending automatic cars or cartridges great distances at enormous speed, have nearly completed their plant and two miles of track at Laurel, Md. The building is 30 by 40 ft., and contains a boiler-room, engine and dynamo-room, and an office. Already the twin boilers of 125 H.P., with a 56-ft. stack, are in position, and the 130 H.P. Ball automatic cut-off engine is ready to run. It has a speed of 300 revolutions per minute. The dynamo for generating electricity is expected from the Sprague Works in New York in about two weeks, and an iron car 30 in. deep, 24 wide and 18 ft. long will be turned out within five days. The machinery for the car is to come from the Sprague Works. The electric connections will require about a week to make. Various experiments will be made to get the best results possible by Mr. David G. Weems, the inventor, and Messrs. George H. Tegmeyer and B. J. Dashiell, the engineers. The car, which is pointed at the prow, runs on wheels 28 in. in diameter on tracks 28 in. apart. The electricity comes from a central upper rail. The brakes will be worked by electricity. It is claimed that from where the plant now stands cars could be run from Baltimore to Washington and return loaded with mails and unattended by any one.

## Manufacturing Notes.

A LARGE patented screw-power testing machine of 100,000 tons capacity, with all the recent improvements, has been erected at the United States Navy Yard, Boston. It was built by Messrs. Riehle Brothers, Philadelphia, the same firm who supplied the testing machine to the United States Navy Yard at Mare Island, Cal., also at the Naval Academy at Annapolis, and the United States Military Academy at West Point, and have furnished in all nearly 30 of their testing machines to the United States Government alone. The machine at the Boston Navy Yard was critically examined and reported upon by a special board of naval engineers, appointed by G. W. Melville, Chief of the Bureau of Steam Engineering, the report being very favorable. Another testing machine will be shipped shortly to the Thompson Electric Welding Company, of Lynn, Mass.; one to the famous ship-building firm of Hereshoff & Company, Bristol. R. I.; and one to the Dennis Long Company, of Louisville, Ky.

THE Southwark Foundry & Machine Company, Philadelphia, intends making extensive improvements to the now very large plant. Two traveling cranes of 30 and 50 tons capacity will be put in the shops. There are at present under way four centrifugal pumps, with their engines and boilers, two of which are for the Norfolk Navy Yard dry dock, and two for that at the Brooklyn Navy Yard. Each of these pumps is capable of discharging 40,000 gallons of water per minute, and are similar to those made for the Mare Island Navy Yard dock at California. They are also making the pumps for the dry dock at Newburyport.

THE Cobb Vulcanite Wire Company, Wilmington, Del., is putting in new machinery which will more than double its plant, making the works the largest manufactory of insulated wire in this country. The works are now running to their full capacity, but are still behind with their orders.

THE Tanite Company, Stroudsburg, Pa., is continually devising and introducing new uses for emery. Among the latest are a solid emery oil-stone, which is a stone or block of convenient size for sharpening tools, and is similar in quality to the Tanite emery wheels. Two grades of these stones are made; one for putting on a rough edge, and one for a cutting edge on fine tools. The rough edge stone will do the same work that a grindstone will. Another, intended for household use, is a knife-sharpener, which personal experience has shown to be of excellent quality.

THE Ranken & Fritsch Foundry & Machine Company, St. Louis, successors to the Smith, Beggs & Ranken Machine Company, are proceeding rapidly with the improvements at their extensive establishment. The work of adding another story to the erecting shop will be completed shortly, when a large amount of new machinery, including a planer much larger than any at present in St. Louis, a new boring mill, and other new and improved tools, will be put in.

THE Westinghouse Air-Brake Company has made a contract with the American Brake Company, of St. Louis, under which the Westinghouse obtains control of the American Company's patents and guarantees the latter a certain interest on its capital stock. The contract has been ratified, and the Westinghouse Company has taken full possession.

## Marine Engineering.

THE new steamship *Corona*, built by Messrs. Neafie & Levy, of Philadelphia, for the Oregon Improvement Company, is about completed. She is built entirely of steel, and is 235 ft. long, 36 ft. beam and 23½ ft. depth of hold. She is schooner-rigged, the masts entirely of steel. She has accommodation for 125 cabin and 50 steerage passengers, while no expense has been spared for their comfort. The joiner work was done by Messrs. Hoffmire & Son, of New York. The machinery consists of the vertical triple expansion, surface condensing engines, expected to develop 1,350 I.H.P. with a steam pressure of 150 lbs. and making 150 revolutions. The cylinders are 20, 31 and 51 in. diameters by 36 in. stroke of pistons. Piston slide valves on all cylinders are worked by eccentrics in the usual manner. The air and circulating pumps are driven off the main engine by side levers. One side of the engine is open, formed of strong wrought-iron columns, thus making all working parts very accessible and convenient for lining up. The boilers are of steel, four in number, 10 ft. in diameter by 11 ft. long, each having two corrugated furnaces, manufactured by the Continental Iron Works, of Brooklyn, N. Y. The vessel is steered by Williamson's patent steering gear, and has also four hoisting engines of their make for discharging cargoes.

Two steam capstans and a steam windlass of the American Ship Windlass Company's make have also been put on, and are of their latest and most approved pattern. The rigging, which is entirely of steel, was done by Charles Thomas & Sons, of Philadelphia.

THE Harlan & Hollingsworth Company, Wilmington, Del., has made a contract to build a new ferry-boat 158 ft. long, 55 ft. over all, and 12 ft. deep for the Camden-Philadelphia ferry. She will have a beam engine with cylinder 42 in. diameter and 10 ft. stroke. The same company is to build a yacht 112 ft. long, 18 ft. beam and 12½ ft. deep for Dr. W. Seward Webb. The yacht will be built of the best open-hearth steel throughout, both in plating and beams and angles, and will be furnished with motive power by a triple-expansion compound engine of latest design, and a patent upright tubular boiler, for a working pressure of 160 lbs. of steam.

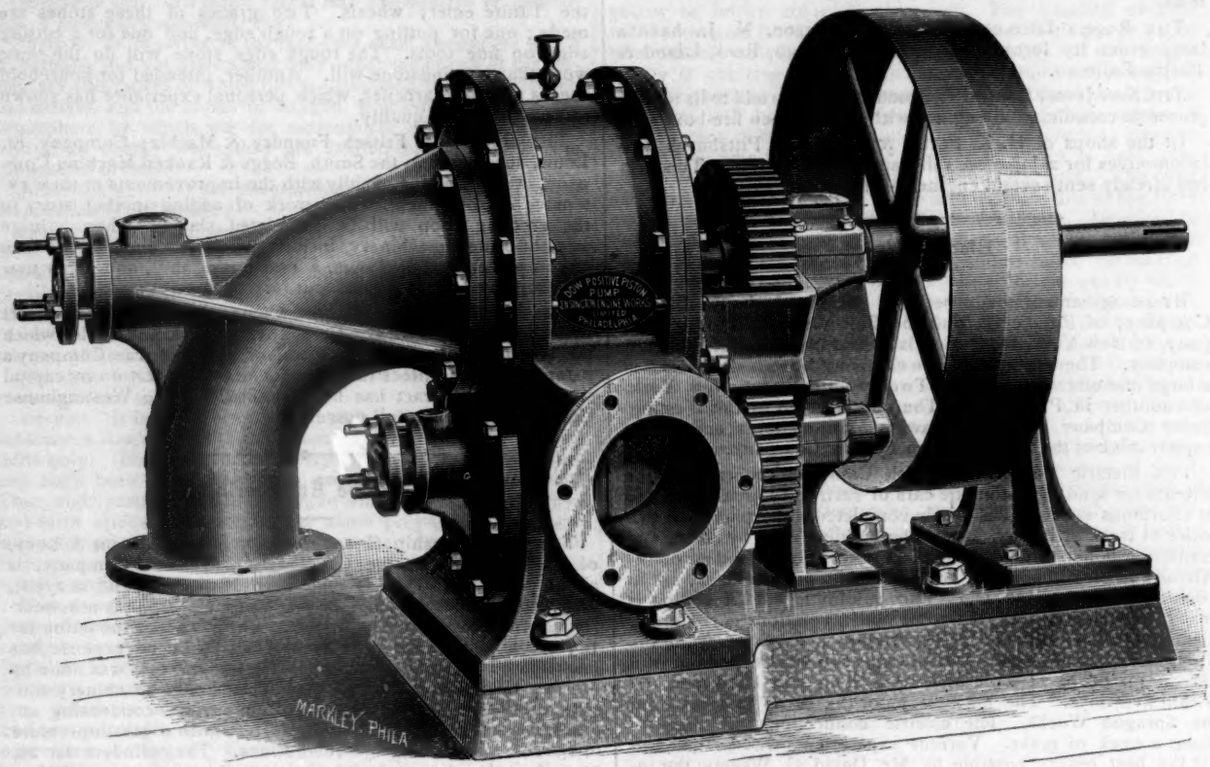
THE new steel twin-screw ferry-boat *Bergen* recently launched at Newburgh, N. Y., for the ferry between New York and

Hoboken, is the first large boat of this kind built in this country, except one on the Detroit River.

The *Bergen* is 200 ft. long, 37 ft. wide over the plating, 55 ft. wide over all, with a draft of 8 ft. 9 in., and a depth of 14 ft. Her cabin will be a clear interior 125 ft. long by 15 ft. wide.

The propeller shaft extends the whole length of the boat, carrying on each end a cast-steel propeller wheel 8 ft. diameter and 9 ft. 3 in. pitch. The engine is of the triple-expansion type, with cylinders 18½, 27, and 42 in. diameter and 24-in stroke. The working pressure will be 160 lbs.

THE Cleveland Ship-Building Company recently launched the steel steam barge *Transfer*, built for the Michigan Central Railway Company to be used as a railroad ferry-boat at Detroit. Her length over all is 280 ft., 45 ft. 6 in. beam, 17 ft. 3 in. hold, and 75 ft. from outside to outside of guards. It is estimated that she could break through ice 3 ft. thick without injury, and could be sailed through ice 1 ft. in thickness at a speed of seven miles per hour. Her screw wheel is 9 ft. in diameter, and her side wheels are shod with heavy steel facings to assist in breaking ice. The power which is to push her through water or ice of above thickness is in four steel boilers 11 ft. 6 in. diameter, 16 ft. long, or 4½ ft. longer than the longest ordinary boilers on the Lakes. These boilers have two domes 20 ft. long and 48 in. in diameter, and one dome 10 ft. long and 6 ft. in diameter. These boilers will furnish steam for six cylinders: two 28 × 28 in. on each side for the side-wheel engines, and two cylinders 28 × 36 in. for stern-wheel engine, each with separate condensers.




THE DOW POSITIVE PISTON PUMP.

## The Dow Positive Piston Pump.

THE accompanying illustrations show the Dow "positive piston" pump, fig. 1 being a perspective view and fig. 2 a section.

This pump is of an entirely new type, the builders of which claim that it fully and efficiently realizes the long-sought-for perfect action of a piston (or plunger) moving in one direction only, and that it overcomes many difficulties encountered in all other pumps; among them the resistance produced in reciprocating plunger pumps through necessity for reversing the motion of the current within the chamber (a resistance increased with the speed), also that caused by subdivision in passing small valve openings, and the impact of the fluid against the valves themselves, which offer a direct impediment to the flow.

This pump avoids loss of power and excess of wear and tear, as no work is done upon the fluid within it except to move it directly forward in a freely open channel. These and other advantages herein described result in an unusually large capacity in proportion to the power used, and permit a high rate of speed without concussion or disagreeable vibration. The action is as positive under a low rate of speed, and at any speed remarkably quiet.

The "Positive Piston Pump" has two annular chambers side by side, surrounding an internal cylinder (and separated by the central partition); in each of these chambers moves a single piston, with its strengthening wings, making the pump duplex in its action. The pistons are so placed that a perfect balance of all the parts, and of the fluid moving through them, is maintained. The suction is central, passing through the internal cylinder, which is attached to and revolves with the main shaft. This cylinder supports the pistons, and has openings behind them, between their strengthening wings; screw propeller-shaped suction blades within the cylinder lead to these openings through which the fluid passes, drawn by action of the pistons, which, in their travel, cause a suction in the same manner as with a reciprocating plunger, the ends of the annular chambers being completely closed by the abutment cylinder which is in close contact and revolves in equal time with the piston cylinder, the closing being aided, when necessary for very high heads or use as a fire-pump, by an efficient packing. The movement of the fluid is aided, as it flows through the internal cylinder from the center outward to the annular chambers, by the suction blades and by centrifugal force. Through an opening in the abutment cylinder the piston finds passage, but immediately after it the closing is again made perfect.

While the suction is taking place behind the pistons, the contents of the chambers before them are being continually forced through the discharge opening, which is in a direct tangent to the action of the pistons, and presents a free course to the current, which is equal in volume to the displacement. When high suction is to be obtained without priming, two hinged valves are provided in the discharge opening, one for each chamber, and are dropped upon their seats to control the great elasticity of air; the suction is then readily obtained. Upon establishing the current, these valves are raised and held completely out of it, they being no longer of use. No frictional contact of the moving parts with each other or with the case has been found necessary to secure and maintain the full current. With very high lifts, however, an efficient packing is used. The wear is almost entirely confined to outside journals, and therefore readily controlled.

One of the important applications of this pump has been to run it with a belt or otherwise at comparatively low speed, for

ordinary use, and with a coupling to readily connect with a high-speed shaft for extraordinary supply or use as a fire-pump. As the pump runs equally well at high or low speed, the discharge can be regulated at will.

This pump, it is claimed, is the most economical machine yet discovered for lifting large or small volumes of water. It has been thoroughly tested in service.

The same principle has been applied to a blower and a pressure blower, with excellent results.

The Kensington Engine Works, Limited, Beach and Vienna streets, Philadelphia, are the sole licensees and manufacturers, under the American and foreign patents of Josiah Dow.

## Cars.

THE Union Switch & Signal Company, Swissvale, Pa., has arranged for the exclusive right to manufacture and sell a new form of car buffer invented by Mr. George Westinghouse, Jr., which, it is believed, will meet a heretofore unfilled want—namely, a device offering resistance to the inward movement of the draw-bar sufficient to absorb in itself the momentum of the load in ordinary working in such a way that the shock and consequent injury to the car, heretofore considered inevitable, will be obviated. The device in question consists of a cast-iron box containing a number of thin plates secured to it, and a like number of thin plates placed between those in the box and attached to movable pieces against which the draw-bar presses. When the draw-bar is pressed inwardly these thin plates are, by a simple wedge device, clamped or squeezed together so as to offer an immense frictional resistance to further inward movement, which together with the resistance of the main springs (the same as heretofore used), absorbs such an amount of momentum that it is possible to run one car into another at a speed of eight or ten miles an hour without fully exhausting the frictional resistance and compression of the springs. Not only do the friction plates of the buffer offer an immense resistance, but the reaction of the main springs is prevented, thus assisting materially to decrease the risk of breaking trains in two. The apparatus is simple in construction, and is applicable to any form of draw-bar, but will be particularly valuable in connection with the Janney type of coupling, which does not at all times admit of the action of the dead-blocks. The apparatus has been designed with reference to securing uniformity in draw-gear, and is applicable to all classes of cars, freight and passenger, and its peculiar construction admits of a new method of attaching draw-gear, which will give all the practical effect of a continuous draw-bar, if desired.

THE works and warehouse of Joel H. Woodman & Company, New York, have recently been altered and improved, to meet the requirements of their large business in car-seats, head-linings and general veneer work. This firm makes a specialty of railroad and car work, carrying a great variety of designs. A branch house in London is also doing an excellent business.

THE Pennsylvania Company's shops at Fort Wayne, Ind., have just completed 200 Union Line box cars of 60,000 lbs. capacity, and are now at work on an order of 75 stock cars which are to be equipped with air brakes and Janney couplers.

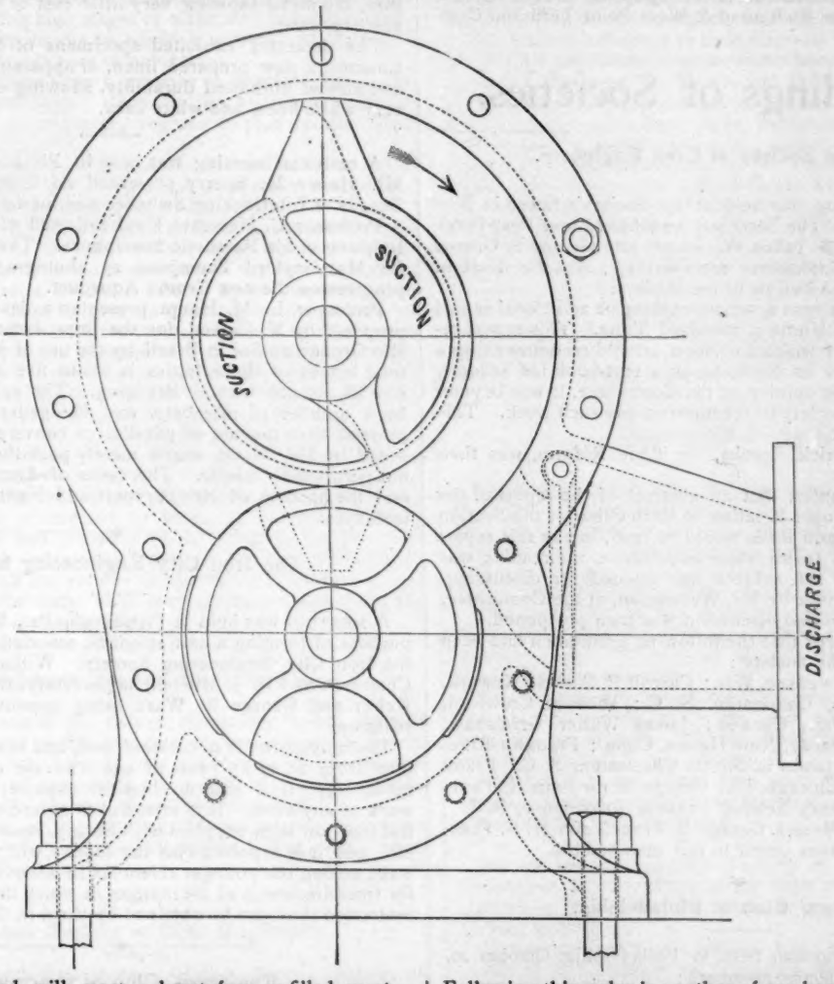



Fig. 2.

Following this order is another of 100 box cars. All these cars are equipped with a standard draft-rigging, and so arranged that at any time, should it be desired, the Janney coupler may be substituted for the wrought-iron draw-bar now in use, without changing the draft-rigging.

THE Treat Car-Wheel Works, Hannibal, Mo., are building a branch foundry at East Chicago, which will have a capacity of 400 wheels per day.

THE Milton Car Works, Milton, Pa., have an order for 500 box and 500 coal cars for the New Jersey Central Railroad.

THE Erie Car Works, Erie, Pa., are busy on several large orders for freight cars.

THE Laconia Car Company, Laconia, N. H., is building 200 box cars for the New York, Lake Erie & Western Railroad, fitted with the Eastman car-heater. They will be used to carry fruit and similar freight.

THE car shops of McKee, Fuller & Company, Catasauqua, Pa., are building 2,000 coal cars for the Lehigh Valley Railroad.

THE shops of the United States Rolling Stock Company at

Anniston, Ala., are building freight cars for the Alabama Great Southern and the Georgia Pacific roads.

THE Ohio Falls Car Works, Jeffersonville, Ind., are building a number of freight cars for the East Tennessee, Virginia & Georgia Railroad.

IT is stated with authority that an organization, to be known as the Union Palace Car Company, has been formed by parties holding a controlling interest in the Mann Boudoir and the Woodruff Sleeping-Car companies. A large interest in these companies had been acquired by the Jackson & Sharp Company and the Harlan & Hollingsworth Company, of Wilmington, Del., in whose workshops many of the cars for the Mann and Woodruff companies have been built and stock largely taken in payment therefor. It is stated that the new company has been organized with a capital of $3,000,000. Contracts have been placed by the new company with the Jackson & Sharp and the Harlan & Hollingsworth companies for the building of 34 sleeping-cars, and the Union Company has also perfected arrangements for the exclusive use of its cars upon the lines of railroad now controlled by the Richmond & West Point Terminal Company.

# Proceedings of Societies.

## American Society of Civil Engineers.

A REGULAR meeting was held at the Society's house in New York, November 7. The Secretary announced that Past-Presidents W. J. McAlpine, Julius W. Adams and George S. Greene had been elected to honorary membership; also the death of Springer Harbaugh, a Fellow of the Society.

The Secretary then read a supplementary or additional report of the Committee on Uniform Standard Time. This report referred to a resolution which had been offered recommending a treatise on Time and its Notation as a text-book for schools, and stated that, in the opinion of the Committee, it was beyond the province of the Society to recommend any such work. This report was approved.

A paper by Frederick Brooks, on Time Reform, was then read.

It had been announced that an abstract of the report of the Committee on the Proper Relation to Each Other of the Section of Railroad Wheels and Rails would be read, but as this report had been distributed to members in advance, the reading was dispensed with, and the subject was opened for discussion. Some remarks were made by Mr. Wellington, of the Committee, and the written and verbal discussion was then postponed.

The tellers announced that the following gentlemen had been elected members of the Society:

Jacob N. Barr, Milwaukee, Wis.; Carroll P. Bassett, Newark, N. J.; William Cain, Charleston, S. C.; William Crawford, Sault Ste. Marie, Ont., Canada; James Walter Grimshaw, George Richardson Hardy, New Haven, Conn.; Franklin Rifle, Wallula, Wash.; Benjamin B. Smith, Charleston, S. C.; Frank Sherman Washburn, Chicago, Ill.; George Blinn Francis, Providence, R. I., and Henry Newton Francis, Providence, R. I.

Of these members Messrs. George B. Francis and H. N. Francis were transferred from junior to full membership.

## Engineers' Club of Philadelphia.

A REGULAR meeting was held in Philadelphia, October 20. The following were elected members:

Charles H. Davis, William E. Good, James Murray Africa, E. A. Herring, H. Kauffman, Jr., James D. Moffet, R. Taylor Gleaves, and Charles Lundström.

The Committee to which was referred communications from the Western Society of Engineers and the Engineers' Club of Kansas City, in relation to design and inspection of highway bridges, presented a report recommending that a State Engineer should be appointed in each State who should have a general supervision of bridge structures, and that plans and strain sheets of bridges should be open to inspection. The Committee also recommended co-operation with other societies on this point, with a view of obtaining necessary legislation.

Mr. H. W. Spangler presented a paper on Multiple Expansion Engine Cards; this was followed by a short discussion. Mr. C. A. Lundstrom presented a paper on the Theory of Elastic Curves.

Mr. R. P. Snowden exhibited two specimens of old rails, a small and a large section.

The small rail is a piece of the first rail used by the Camden & Amboy Railroad, weighing about 20 lbs. per yard. This rail was laid on a beveled stringer, and spiked only on the outside of rail. About eight miles of this was laid from Cooper's Creek eastward. It was found unsuitable, causing many accidents. No splice was used, and the ends curled up, making "snake-heads," as remembered by some of our older members. It was replaced by English rail, 40 lbs. per yard, of a pattern similar to the old 67-lb. rail of 1878.

The large section is a piece of 7½-in. rail, laid about 1847, near Bordentown shops, Ernston and Camden. It was of slightly differing sections, weighing about 90 lbs. to the yard, and was put down as an experiment. It was laid with wooden joints. The experiment was unsuccessful, the height of rail making it impossible to keep it from turning over, even with the wooden brace blocks which were put on soon after the rail was laid.

Some discussion took place over these specimens.

The Secretary exhibited for Mr. F. H. Taylor a section of a hand-rail, taken from a bridge over a railroad track and sent to illustrate the effects of gases, etc., from smoke-stacks upon iron, the metal showing very little rust or injury from weather and exposure.

The Secretary exhibited specimens of blue prints made on Linaura, a new prepared linen, of apparently excellent quality and almost unlimited durability, showing excellent blue color, very white lines, and white back.

A REGULAR meeting was held in Philadelphia, November 3. Mr. Henry M. Sperry presented an illustrated paper on the Details of Interlocking Switches and Signals.

Professor C. Herschel Koyl followed with an illustrated description of his Parabolic Semaphore. The Secretary exhibited for Mr. Gaylord Thompson 15 photographs of the work in progress on the new Croton Aqueduct.

Professor L. M. Haupt presented a description of the plan proposed by M. Caland, for the improvement of the bar of the Rio Grande do Sul in Brazil by the use of jetties in bars. The total length of these jetties is about five miles, the estimated cost $8,000,000 without dredging. The subject was discussed by a number of members, and the general opinion was expressed that the use of parallel or convergent jetties, as proposed by M. Caland, would merely push the bar seaward without permanent results. The cases of Aransas Pass in Texas and the harbors of Newburyport and Nantucket were cited as instances.

## The Iron City Engineering Society.

A MEETING was held in Pittsburgh, Pa., November 8, for the purpose of forming a new scientific association, to be known as the Iron City Engineering Society. William Hazlett acted as Chairman and N. J. Mitchell as Secretary, the latter with H. E. Kellar and George R. Ward being appointed to draft a constitution.

The movement is a national one, and is intended for young men from 18 to 25 years of age who are actively engaged in metallurgy, civil and mechanical engineering, and electrical work of any kind. It is intended to secure rooms in some central location to be supplied with library, reading-room, cabinets, etc., and it is expected that the society will supply a much-felt want among the younger scientists in affording an opportunity for freer discussion of the matters in which they are immediately interested than can be obtained by them in the older societies.

## Engineers' Club of Cincinnati.

THE fifth regular monthly meeting of the Club was held October 3. Three new members were elected, increasing the membership to 67.

Mr. G. Bouscaren presented an interesting description of the works he is now constructing to secure a water supply for the city of Covington, Ky. They consist (1) of a pumping plant and supply aqueduct on the left bank of the Ohio River, about one mile above the mouth of the Little Miami; (2) of the reservoir on the bluffs above, three-fourths of a mile from the pumping-house and four miles from the center of Covington, from which it is separated by the Licking River; and (3) of the force-pipe leading into the reservoir and the distributing mains leading therefrom.

The water will be taken from the Ohio River into the well of the pumping-house, through a circular arch of masonry 4 ft. in internal diameter and 158 ft. long, calculating to supply a pumping plant of 20,000,000 gallons in 24 hours.

The reservoir is formed by damming a branch of Three Mile

Creek below one of its bifurcations; partition dams across each fork dividing the reservoir into three basins.

The dams are of earth, the water slope being 3.1 and faced with puddle. The sides of the basin have a uniform slope of 3.1, which, with the bottom, is revetted with concrete.

A 30-in. force-pipe of graduated thickness (1¼ in. to 1 in.) leads to the reservoir, ascending the river bluff with an average grade of 20 ft. in the 100. A 30-in. distributing main leads from the reservoir to Covington (19,873 ft.).

The total cost of the work is $979,000.

THE sixth regular monthly meeting of the Club was held November 7. Seven applications for membership were presented and one member elected, increasing the membership to 68.

Colonel William E. Merrill addressed the Club, his subject being Movable Dams in General and the Davis Island Dam and Lock.

He briefly defined movable or adjustable dams as those which can be lowered during high stages of water and raised into position again when the supply of water is so small as to require pooling, to serve the purpose of navigation.

He discussed various French systems of movable dams, also the American "Bear-Trap," which utilizes hydraulic pressure, and is much used in lumbering regions to pass lumber down streams on artificial waves.

At Davis Island, in the Ohio River, five miles below Pittsburgh, Colonel Merrill has constructed a movable dam in four sections, having an aggregate length of 1,223 ft.

Although the Davis Island Dam has been in successful operation for three years, the exceptionally large quantity of drift-wood, and occasionally of ice in this part of the river, has given so much trouble that a bear-trap is now under construction in the middle of the dam, to give an opening for the passage of the drift and ice. The lock rendered necessary by this dam is 110 ft. wide to allow the passage of four coal barges abreast. Its length is 600 ft. between gates. The ordinary miter gates being deemed inapp'icable to a lock of such great width, the lock is closed at either end by a single gate 114 ft. long. These gates are operated by steam, moving on rollers into recesses in the landward wall of the lock. There are 14 filling culverts, each 54 in. diameter and closed by a circular balanced valve on a vertical axis, half in the river wall and half in the upper gate recess. The lock is emptied by seven 54-in. culverts in the lower gate recess and fourteen 38-in. openings in the lower gate. The last are operated by hand, all the rest by hydraulic pressure. The lock can receive at one time a tow-boat, 10 coal barges, and two fuel flats, while six passenger steamboats can be locked through at one lockage.

## Engineers' Club of St. Louis.

THE first meeting of the season, November 7, was devoted to a supper in honor of the twentieth anniversary of the founding of the Society, which was largely attended and much enjoyed.

At the meeting of November 21 a paper on Smoke Prevention was read by Mr. Robert Moore and discussed.

The programme of the meetings for the season includes a number of interesting and valuable papers. The annual meeting will be held December 5.

## Montana Society of Civil Engineers.

A REGULAR meeting was held in Helena, Mont., October 20. A committee was appointed to co-operate with committees of other societies, in the matter of Reform in the Construction and Inspection of Highway Bridges. A committee was also appointed to report on the dangerous crossings of some of the streets in Helena by the new Motor Line.

Mr. E. O. Goodridge read a paper on the Ingersoll Rock Drill, with special reference to its use in the construction of the Wickes Tunnel. This paper was discussed by the members present.

## Engineers' Club of Kansas City.

A REGULAR meeting was held November 5, 1888, President W. B. Knight in the chair.

Mr. W. H. Breithaupt read for the Committee on Highway Bridge Reform the draft of a law prepared to be presented with a memorial to the State Legislature.

The Secretary announced several contributions to the library.

A paper on Electric Railroads was read by Mr. T. F. Wynn, and discussed by members present.

The programme for the winter is as follows:

December 3. The Steam Engine; its Beginning, Growth and Place in the Industries of To-day, by C. A. Burton.

December 5. Reports of Officers and Committees. Nomination of Officers for 1889.

January 7. Election of Officers for 1889. Address of Retiring President, William B. Knight.

January 21. Electric Railroads, by A. N. Connett.

February 4. The Details of Iron Highway Bridges, by E. W. Stern.

## Technical Society of the Pacific Coast.

AT a regular meeting held in San Francisco, November 2, E. J. Molera in the chair, Marsden Manson, Chief Engineer of the San Francisco Harbor Commission, read a very interesting paper on the Swamp Lands of California. He briefly reviewed the manner in which the lands had been acquired by the State from the Federal Government, and the subsequent legislation in this State in reference to their disposition. The swamp lands are divided into three classes—those bordering the bays, those along the deltas of the rivers, and those bordering the lakes. Of salt marsh lands there are about 320 square miles. In all about 203,000 acres have been reclaimed on the bays, and 1,000,000 acres along the rivers. About $14,000,000 has been spent by the Government and by individuals in reclaiming these lands. Mr. Manson then reviewed the work that is being done. He stated that nowhere in this country is there such a large dredging plant, and that the amount of earth being handled was next to that on the Panama Canal. He regretted that there was not a general system under which it was being done. Each company or individual was going on independently of everybody else, and although they were in dead earnest and have vast sums at stake, he feared that they were frequently working at cross-purposes so far as the general success of the reclamation of large districts was concerned.

## Western Railway Club.

THE regular monthly meeting was held in Chicago, October 23. Mr. J. N. Barr was elected Second Vice-President. A report was received in favor of publishing the proceedings in pamphlet form. This report was approved and the Committee directed to have them published. It was resolved to fix the date of the meetings the third Tuesday of each month.

The discussion of Mr. Hickey's paper on the Circulation of Water in Locomotive Boilers, which was read at the September meeting, was continued by Messrs. Hickey, Forsyth, Barr, Slack, Cushing and others.

The subject of Materials for Car Construction was then taken up, and was introduced by Mr. Barr, who spoke with especial reference to Wheels. Messrs. Forsyth, Verbryck and other members continued the discussion.

The meeting was closed by a short discussion on the Steam Heating of Cars, in which the merits of the Sewall, Baker and other systems were presented.

AT the regular monthly meeting of this Club in Chicago, November 20, the subjects for discussion were Combustion, opened by Mr. C. M. Higginson, of the Chicago, Burlington & Quincy Railroad.

Wheel and axle for 60,000-lbs. cars; size and quality.

Mr. G. W. Ettenger read a paper upon the use of Iron as a Material for Building Cars.

## Franklin Institute.

THE programme for the December lectures is as follows:

December 3. Introduction to Course on Chemistry; Dr. Persifor Frazer.

December 10. Edison and his Inventions; W. J. Hammer, of Boston.

December 17. Some New Phenomena in Acoustics; Professor W. Le Conte Stevens.

The Committee on Science and the Arts desire to call attention to the two medals at their disposal: 1. The Elliott Cresson gold medal either for some discovery in the arts and sciences, or for the invention or improvement of some useful machine, or for some new process, or combination of materials in manufactures, or for ingenuity, skill or perfection in workmanship.

2. The John Scott medal, with premium of $20 in gold for useful inventions.

Upon request therefor, from interested parties, made to the Secretary of the Franklin Institute, full information will be sent respecting the manner of making application for the investigation of inventions and discoveries; furthermore, the Committee on Science and the Arts will receive and give respectful consideration to reports upon discoveries and inventions, which may be sent to it with the view of receiving one or the other of the awards herein named, and full directions as to the manner and form in which such communications should properly be made, will be sent on application.

### American Street Railway Association.

AT the convention held in Washington, October 18, the following officers were elected: President, George B. Kerper, Cincinnati; First Vice-President, Jesse Metcalf, Providence, R. I.; Second Vice-President, Henry Hurt, Washington; Third Vice-President, W. H. Martin, San Francisco; Secretary, W. J. Richardson, Brooklyn, N. Y. Executive Committee, Charles B. Holmes, Chicago; John Scullin, St. Louis; James H. Johnston, Savannah, Ga.; Henry A. Sage, Easton, Pa.; Edward J. Lawless, Kansas City, Mo.

### American Institute of Architects.

AT its annual convention held at Buffalo, N. Y., in October, the following officers were elected: President, R. M. Hunt, New York; Secretary, A. J. Bloor, New York; Treasurer, O. P. Hatfield, New York. Board of Trustees: E. T. Littell, N. Le Brun, George A. Frederick, W. W. Clay. Committee on Education: W. R. Ware, N. C. Ricker, J. McLaughlin, W. G. Preston. Committee on Publication: T. M. Clark, Charles Crapsey, W. R. Briggs, G. C. Mason, Jr., W. G. Preston. Secretary for Foreign Correspondence: R. W. Gibson.

### Master Car-Builders' Association.

LIST of subjects, with the committees appointed to report thereon, at the Annual Convention of the Master Car-Builders' Association, to be held June, 1889.

1. To Formulate a Code of Rules for the Interchange of Passenger Cars, including Sleeping, Parlor, Chair, Baggage and Express Cars.—T. A. Bissell, Wagner Palace Car Company, Buffalo, N. Y.; John W. Cloud, New York, Lake Erie & Western, Buffalo, N. Y.; Eugene Chamberlain, New York Central & Hudson River, East Buffalo, N. Y.

2. Standard Journal-box Lid for a Sixty-thousand pound Car and a Standard Lid for a Forty-thousand pound Car.—J. W. Marden, Fitchburg, Boston, Mass.; William McWood, Grand Trunk, Montreal, Canada; L. Packard, New York Central & Hudson River, West Albany, N. Y.

3. Standard Brake Gear for Air-Brake Cars, with a Brake Shoe for Iron Beam.—E. B. Wall, Pittsburgh, Cincinnati & St. Louis, Columbus, O.; George Hackney, Atchison, Topeka & Santa Fé, Topeka, Kan.; Godfrey W. Rhodes, Chicago, Burlington & Quincy, Aurora, Ill.

4. Journal Lubrication and Best Practice for Economizing Oil.—John W. Cloud, New York, Lake Erie & Western, Buffalo, N. Y.; H. Roberts, Chicago & Grand Trunk, Detroit, Mich.; J. N. Lauder, Old Colony, Boston, Mass.

5. Buffers and Carrier Irons for the Master Car-Builders' Type of Coupler and a Standard Length of Draw-Bars.—Charles F. Schroyer, Chicago & Northwestern, Chicago, Ill.; E. W. Grieves, Baltimore & Ohio, Baltimore, Md.; E. B. Wall, Pittsburgh, Cincinnati & St. Louis, Columbus, O.

6. Car Heating and Lighting. (This Committee was instructed to select a steam coupler to be submitted to letter-ballot for adoption.)—Frank L. Sheppard, Pennsylvania Railroad, Altoona, Pa.; R. D. Wade, Richmond & Danville, Washington, D. C.; Robert Miller, Michigan Central, Detroit, Mich.

7. Wheels. (This Committee was instructed to ascertain from the members of the Association whether the recommendations of their report would be acceptable to them, and from the replies received and the further experience which they may get during the coming year, to formulate a report, with recommendations, which can be submitted to the next meeting of the Association for letter-ballot, their recommendations to be adopted as a standard, if they meet the approval of the Association.)—J. N. Barr, Chicago, Milwaukee & St. Paul, Milwaukee, Wis.; John Kirby, Lake Shore & Michigan Southern, Cleveland, O.; George F. Wilson, Minneapolis & St. Louis, Minneapolis, Minn.

8. Standard Axle for 60,000 lbs. Car. (This Committee to report a form and the dimensions for such a standard axle at the next Convention.)—Godfrey W. Rhodes, Chicago, Burlington & Quincy, Aurora, Ill.; John S. Lentz, Lehigh Valley, Packerton, Pa.; R. McKenna, Delaware, Lackawanna & Western, Scranton, Pa.

### Interstate Commerce Commission.

THE following circular has been issued by the Commission:

"The Bureau in charge of the Auditor will hereafter be known as the Bureau of Rates and Transportation, Auditor C. C. McCain remaining at the head thereof.

"In view of the importance of providing for an exhaustive compilation of statistics from the annual reports of carriers, and the great amount of detail work involved, a Bureau of Statistics has been established which is in charge of Professor Henry C. Adams, Statistician.

"All freight tariffs, passenger tariffs, classifications, rate sheets, circulars, and other printed or written matter relating to rates, together with all contracts, agreements, and traffic arrangements which are required to be filed with the Commission under Section 6 of the Act to Regulate Commerce, and correspondence relating thereto, will be addressed as heretofore to C. C. McCain, Auditor, Interstate Commerce Commission, Washington, D. C.

"Annual reports of carriers under Section 20 of said act, and correspondence relating thereto, will be addressed to Henry C. Adams, Statistician, Interstate Commerce Commission, Washington, D. C."

## OBITUARY.

A. W. LANGE, who died at Roanoke, Va., November 1, was born and educated as a civil engineer in Sweden. After serving for several years on a Swedish railroad he came to this country in 1879, and has since been employed on various works, including the Hudson River Tunnel, the Atchafalaya Bridge on the Texas & Pacific Railroad, the Chestnut Street Bridge, in Philadelphia, and the Norfolk & Western Railroad.

GEORGE D. SPECHT, who died in San Francisco, November 2, aged 37 years, was born in Germany; educated as a civil engineer, and served for a short time on the Austrian State railroads. In 1879 he went to California, where he was employed as Engineer of the Sutro Tunnel, and afterward Assistant Engineer of the Spring Valley Water Works. Mr. Specht was one of the founders of the Technical Society of the Pacific Coast, and a very active member of that Association.

FREDERICK A. POTTS, who died in New York, November 9, aged 52 years, was for many years a prominent and widely-known coal operator and dealer. He was President of the New York, Susquehanna & Western Railroad, which was reorganized and extended under his charge, and was also largely interested in the New Jersey Central Railroad, in which he was a director.

## PERSONALS.

W. H. LEWIS is now Master Mechanic of the Chicago, Burlington & Northern Railroad.

H. M. SMITH is now Chief Engineer of the Rome & Decatur Railroad, now under construction.

JOSEPH M. ROGAN is now Western Agent of the Baker Heater Company, with headquarters in Chicago.

Mr. J. E. BLUNT, late Division Engineer, succeeds Mr. H. G. Burt as Chief Engineer of the Chicago & Northwestern Railroad.

PROFESSOR HENRY C. ADAMS, of the University of Michigan, has been appointed Statistician to the Interstate Commerce Commission.

F. COLLINGWOOD is now a member of the Commission appointed to inspect and report on the masonry of the new Croton Aqueduct.

F. B. SHELDON has been appointed Chief Engineer of the Columbus, Hocking Valley & Toledo Railroad, with office in Columbus, O.

B. F. BOOKER is now Assistant Engineer in charge of main-

tenance of way, buildings, and water service of the Gulf, Colorado & Santa Fé Railroad.

WILLIAM HUNTER has been appointed Resident Engineer of the Atlanta & West Point Railroad and the Western Railroad of Alabama, with office at Atlanta, Ga.

HORACE G. BURT, late Chief Engineer of the Chicago & Northwestern Railroad, has been appointed Chief Manager of the Fremont, Elkhorn & Missouri Valley Railroad.

J. C. S. TABER has been appointed Chief Engineer of the Pomeroy, Middleport & Syracuse Street Railroad, a steam road 10 miles in length at Pomeroy, O. The New York office of the Company is at 44 Broadway.

ALPHONSE FTELEY, late Consulting Engineer, is appointed Chief Engineer of the Croton Aqueduct Commission, New York City, in place of B. S. CHURCH, who has resigned and is appointed Consulting Engineer.

W. W. STEARNS, late of the New Jersey Central Railroad, is now Superintendent of the Eastern Division of the New York, Lake Erie & Western Railroad, succeeding Mr. J. H. BARRETT, who has been appointed Superintendent of Transportation.

T. L. CHAPMAN, formerly Superintendent of Motive Power of the Chesapeake & Ohio Railroad, is now Assistant General Manager of the Safety Car Heating & Lighting Company of New York, and will have especial charge of the Company's relations with the railroads.

WILLIAM H. HOLCOMB has been chosen Vice-President of the Union Pacific Company, and will have the direct management of the company's lines, succeeding the late Thomas J. Potter. Mr. Holcomb was formerly on the Chicago, Burlington & Quincy, then on the Chicago, Burlington & Northern, and for a year past has been General Manager of the Oregon Railway & Navigation Company.

R. H. SOULE, recently General Manager and formerly Superintendent of Motive Power of the New York, Lake Erie & Western Railroad, has been appointed General Agent of the Union Switch & Signal Company, Swissvale, Pa. He will, among other duties, have charge of the sale and introduction of the new Westinghouse Buffer, the manufacture of which the company has added to its other undertakings.

D. H. NEALE has resigned his position as Associate Editor of the *Railroad Gazette*, and sailed for England, November 20. He expects to remain in that country, where he has accepted an excellent position. Mr. Neale has been connected with the *Railroad Gazette* some five years, and has done much excellent work. He is well known as a mechanical engineer of experience in almost all parts of the world, and as a writer of ability.

## NOTES AND NEWS.

**Proposed Dam across the Rio Grande at El Paso.**—Major Anson Mills, of the Tenth Cavalry, at present stationed at Fort Grant, Ariz., has prepared a project to construct a dam across the Rio Grande, four miles above El Paso, Tex., at a place where the bluffs come within 400 ft. of each other and consist of solid rock, and where the bed of the river is also rocky. He proposes to build a dam 60 ft. high of stone and Portland cement, and thus create a lake 14 miles long. This would hold water enough to permanently irrigate the Rio Grande Valley on the Mexican as well as the American side of the river. An irrigating canal could thus be carried past the city of El Paso 70 ft. above its level. The water could be utilized for hydrants and fire-plugs, as the pressure would be ample. The lake thus formed would be from six to eight miles wide and cover 50,000 acres of land, which is not settled and is mostly owned by private parties. This would have to be purchased or condemned by legal process. The plan is very favorably received by the citizens of El Paso, and will probably be acted upon. It would also supply water-power to run all the factories in El Paso. Major Powell, Director of the United States Geological Survey, is said to approve the plan as practicable, and he proposes to establish a station to measure the flow of the river and determine the amount of sediment. It is proposed to make the dam an international affair.

**Swedish Rapid-Fire Gun.**—At the Copenhagen Exhibition is shown the first specimen of a new Swedish rapid-firing gun, designed by Mr. Harald Thronsen, and manufactured at the large and celebrated establishment of Finspongs, Styckebruk, Sweden. It is capable of firing 18 shots per minute with one man, while with two men it has a capacity of one shot every other second, or 30 shots per minute; caliber 47 millimeters; length about 52 calibers, and the distance from the base of the projectile to the mouth of the barrel 40 calibers. The muzzle velocity is 2,141 ft. (657 meters) per second, with a charge of 750 grammes of Swedish field-artillery powder; the maximum pressure in the barrel has been 2,300 atmospheres. The mechanism is both simple and strong.

**Austrian Locomotive Building.**—The Vienna papers note that a number of orders for new locomotives have recently been given with the approval of the Government. The Imperial Austrian State Railroad has ordered from the Wiener-Neustadt Works four fast passenger locomotives, two eight-wheeled coupled freight engines, three light locomotives for branch service, and two four-wheeled tank engines; from the Floridsdorf Locomotive Works four six-wheeled coupled engines, one eight-wheeled coupled freight engine, and four tank engines; from the Ringhoffer Works at Smichow 11 six-wheeled tank engines.

The Kaiser Ferdinand Railroad has ordered from the Wiener-Neustadt Works 14 six-wheeled tank engines. It is stated that contracts are now pending for not less than 125 engines for the new branch railroads (*localbahnen*).

**The Champerico & Northern Transportation Company of Guatemala.**—A concession was granted, in 1881, by the Government of Guatemala to Messrs. J. H. Lyman, D. P. Fenner, and T. B. Bunting, citizens of the United States, to build a railroad between the port of Champerico, on the Pacific coast of the Republic, to Retalhulen, a point about 28 miles in the interior.

The concession was for the term of 99 years from the date of the opening of the road to public traffic. For a term of 25 years from the same date the road was to be free from taxation and maritime duties, and foreign employés to be exempt from taxation and military service. During the same term also the road is to be protected by the Government from any railroad competition within a distance of 15 Spanish leagues on either side of the line. The right of way was also conceded and station grounds given by the Government, together with free use of its telegraph during the construction of the road and free use of the mails for 25 years for the business purposes of the road. A subsidy of $700,000 in Guatemalan currency was given to the enterprise, to be issued in non-interest-bearing bonds receivable at the custom-house of the Republic in payment of a certain percentage of all duties. A maximum tariff of freight and passenger rates was fixed by the concession, and the road is obliged to carry the mails free and Government employés on duty at half the regular rates.

The road was formally opened for traffic July 4, 1884. Its total cost was about $750,000 in gold. The capital stock of the company is $1,000,000.

From Champerico to Caballo Blanco, a distance of 15¼ miles, the elevation attained is 275 ft., and from this point to Retalhulen, 11¾ miles, the total rise is 500 ft.

Back of Retalhulen the country rises toward the great central ridge, which forms the main part of Central America, and there is a large extent of fine country producing coffee and other products which are carried to Retalhulen by ox-carts and mules.

Quezaltenango, the second city of Guatemala, is 40 miles from Retalhulen, and all its business to and from the sea-coast is done through that point and over the railroad.

**Silicon Steel.**—At the recent meeting of the British Association for the Advancement of Science, a report was presented on the Influence of Silicon on the Properties of Steel. The report last year summarized the results obtained by varying the quantity of silicon added to the purest variety of iron met with commercially, and it was then shown that silicon rendered the metal quiet in the mold, and that in the proportions employed the metal was tough when cold and welded well. The elastic limit and the tensile strength were both increased by the presence of silicon, while the elongation and contraction of area were diminished; the appearance of the fracture also changed from silky to crystalline, and with over 0.13 per cent. of silicon the metal became so red-short that the ingots crumbled to pieces under the rolls. The present report deals with the results obtained by adding silicon to ordinary basic metal. The method of procedure consisted in adding to a weighed quantity of silicious iron melted in a crucible about 40 lbs. of molten metal taken from the ladle about the middle of a cast. After allowing the contents to stand for a minute, the metal was poured into a second crucible to solidify.

In the works tests, all the specimens rolled well, and with one exception behaved satisfactorily under the hot test. The cold or bending test was also satisfactory with the exception of one, in which the phosphorus present was exceptionally high. The presence of silicon has no ill effect upon the welding prop-

erty. The limit of elasticity and the breaking load are higher than usual, while the extension and reduction of area are rather lower than is common with this class of metal. The results are summarized by the committee as follows: On adding silicon in proportions not exceeding 0.5 per cent. to ingot iron containing manganese, the metal rolls well, and does not show any signs of red-shortness; it welds perfectly with all proportions of silicon, and (with the somewhat doubtful exception containing 0.5 per cent.) is not brittle when cold. With less than about 0.15' per cent. of silicon the limit of elasticity, the breaking load, the extension and reduction of area, are but little, if at all, appreciably affected by the presence of silicon; but with more than 0.15 per cent. of silicon the limit of elasticity and breaking load are increased, while the extension and reduction of area are distinctly decreased by the presence of silicon. The effect exerted by silicon in increasing the tenacity of ingot iron is not nearly so great as that of carbon. The relative hardness is very slightly affected by the proportions of silicon used in these experiments.

**Electric Haulage in the Anthracite Mines.**—The introduction of electricity as a motor for underground haulage in the anthracite mines of Pennsylvania is a matter of great interest to mining engineers, since its success or failure will have much to do with its application to the various operations now consuming steam, such as pumping, drilling and hoisting.

The common method of hauling the coal to the main outlets is still by mule power, replaced in some instances, however, by mine locomotives, and in one case only, to the writer's knowledge, in the Schuylkill region, by the endless rope system.

Mine locomotives are, however, very objectionable, and even in some of the recent leases prohibited, on account of the danger to good ventilation caused by the noxious gases thrown off during the combustion of their fuel. In consequence of this they can only be used in the gangways carrying the return current. The electric locomotive avoids this, as well as other objections, since the generator is entirely outside of the mine. It is only limited in its use by the extent of the tracks supplied with the conductor rail or wire.

The Lykens Valley Coal Company at its mines in Dauphin County, Pa., has introduced the electric locomotive with, it seems, considerable success. The road here is 6,300 ft. long, supplied with a third rail carried along the side of the gangway. The average load is 20 cars per trip, or 850 tons per day, equivalent to 1,040 mile-tons per day. The Union Electric Company, which furnished this plant, gives the daily expenses of running the locomotive as $5.71, or a cost per mile-ton of 0.67 cents. This, they claim, can be reduced by the use of better graded roads and heavier mine wagons to 0.40 cents per mile-ton. The writer, in a former paper, gave the relative costs of mule and steam locomotive haulage at Kalmia Colliery, and now introduces them here for comparison with electricity as follows:

| | Mule. | Steam. | Electricity. |
|---|---|---|---|
| Cost per ton-mile.... | 1.82 cents. | 0.60 cents. | 0.40 to 0.67 cents. |

It should be borne in mind that the costs as regards mule and steam power are based upon the prices of 1882, while the estimate for electricity is for 1887, consequently the comparison is not entirely a just one; but it is made to show that we may expect under favorable circumstances electric haulage to at least do the work required as cheaply as steam power, and with less attendant danger to the mine.—*A. W. Sheafer, before Engineers' Club of Philadelphia.*

**Underground Forts in Belgium.**—In a recent number of *La Nature* Colonel Hennebert, of the Belgian Army, describes underground forts, which have come into use in Belgium, as one of the principal methods of national defense. One of these underground forts is like an enlarged molehill, and is built of concrete. Measuring 50 meters in length by from 30 to 40 in width, it is about 12 meters below the surface of the ground, and its greatest height above the earth is no more than three or four meters. It presents the appearance of an elliptical cap placed on the ground, and is scarcely visible to the eye of an observer. At the center of this artficial rock are three armored towers, each with two heavy guns. There are also four small forts, which are pulled in and run out at pleasure, each armed with two rapid-firing guns. At three suitable places there are armored points of observation, from two of which at night the electric light can be flashed to watch the operations of the enemy. Below this surface the earth is hollowed out in the form of a huge well with armored sides, which is divided up into sections, each part protected with heavy armor, one part for provisions and ammunition, another for machinery, which includes the dynamos and accumulators for the lighting of the whole fort, hydraulic machines for working the movable turrets and sending them ammunition, pumps for supplying these machines with water, and a series of ventilators to keep the air pure. Communication with the outer world is made by a subterranean gallery, the length of which varies according to surrounding circumstances. The ceiling of this gallery is from 8 to 10 meters below the surface. To gain access to the fort a hydraulic piston is worked, and this raises a ladder which runs along the whole length of the fort, and lowers the door of the outlet, which is protected by armor 20 centimeters in thickness, and is under the fire of two of the movable forts. All movements, such as changes of guard, arrivals of supplies, etc., are reported by telephone or telegraph. The guard does not work the hydraulic piston, except at command, and when the sentries in one of the movable forts have reconnoitered the visitors. Finally, the gallery communicating with the outer world is strongly fortified by an armored door defended by two mitrailleuses. One of the greatest objections by generals to forts, that they absorb numbers of men who are wanted in the field, cannot be urged against these subterranean forts, for the garrison consists of 30 or 40 mechanics and specialists only, whose absence would not appreciably weaken the regiment from which they are drawn. The cost of one of these forts is only about $500,000.

**Sewage Scheme at Manchester.**—The present plan pursued by the city of Manchester, England, is to empty its sewage into the three rivers passing through it, the Irwell, Irk, and Medlock. Owing to the enforcement of the River Pollution Act of 1876, it has become imperative that the sewage should be collected and purified before being passed into the streams. The natural formation of the land in the city is such that sewers can be conveniently arranged so as to convey the sewage by gravitation toward the western boundary of the city. An inquiry was recently commenced in that city by an inspector for the Local Government Board, into a scheme of sewage interception and disposal designed by the City Surveyor, Mr. John Allison, C. E. The scheme is opposed by the representatives of various local authorities.

The sewage of Manchester is mainly of the domestic class, as is clearly shown by the figures of water consumption. These indicate that 13 gallons of water per head of the population are used for domestic, and seven gallons of water per head for trade and public purposes during every 24 hours. When the new supply of water from Thirlmere is obtained, it is estimated that a larger volume will be used, and it is therefore intended to provide for a daily use of 44 gallons per head. The scheme, as presented by the Rivers Committee, determines the maximum flow at 100,257,000 gallons in 24 hours, for which provision has to be made.

The ruling idea is that of dividing the city up into convenient drainage areas, each of which shall be provided with a main sewer of sufficient capacity; these drainage areas are collected into two groups, which comprise respectively the Irk and Medlock. There is no special engineering work in connection with the construction of these sewers, except in the case of one draining the Strangeways District at the point where it crosses the river Irk. This river is to be crossed by means of a specially designed iron box fitted under the arches. The gradients of the sewers within the city vary from 1 in 18.

At a point between the city boundary and the overflow, a sewer known as Brook's Sewer crosses the trunk sewer at a little higher level. It is therefore proposed at this point to construct a special chamber across which a flat iron pipe of full capacity can be carried, so as not to interfere with the flow of Brook's Sewer. The trunk sewer is between four and five miles in length, and terminates at the precipitation works. Special shafts are provided to permit of easy access being had to the syphon, in order to facilitate examination and cleaning in the event of choking. The precipitation of the sewage is conducted in 20 tanks, each 100 ft. by 60 ft., and 7 ft. deep. The total capacity of the tanks is 4,500,000 gallons. As the sewage approaches the works it terminates in a special chamber, which allows the heavier impurities in the sewage to be deposited. After passing this point the sewage is mixed with a certain volume of lime and alum, and after agitation the whole of the liquid passes into a chamber 188 ft. long, from which it flows into the first of each series of tanks. The method of emptying the sludge is as follows: The sill between each tank is arranged so that by lifting sluice boards at one side a channel is formed. When it is desired to shut off one tank, the sewage is carried along this channel and down each side of the tank on to the sill of the next tank, where it passes over in the usual way. In this way the sewage in the tank is run into a well from which it is raised by a pump, and again passed through the tanks. After the liquid sewage has drained off, a second and lower valve is opened, and the sludge is allowed to pass through a second pipe into a sludge well.

The estimated cost of the whole scheme is to be covered by an expenditure of $2,250,000 for sewers and works, and $200,000 additional for land.

**Utilizing Old Ties in India.**—The following method of utilizing condemned and disused sleepers for strengthening railroad tracks at the rail-joints will, we think, be of interest to all who are engaged in the construction and maintenance of railroads.

However perfect the mechanical fit may be between the contact surfaces of the rails and fish-plates and of the other fastenings, it is not so perfect as to entirely prevent deflection under heavy and rapid live loads. This deflection frequently develops into free play (especially when the fastenings are new), whereby extra pressure is thrown upon the joint-sleepers, and they, in turn, transmit the extra pressure to the ballast.

At this stage the ballast frequently gives way, and the two rails now resemble a girder of about 7-ft. span, with a fish-plate acting as a cover-plate, as represented in fig. 1.

It will be seen at a glance that enormous strains are thrown upon the joint fastenings, and that if the ballast is not promptly packed up, the safety of the line is jeopardized. There is, of course, the bending moment of the rail to be reckoned upon, but even this does not afford a safety margin. It is, therefore, evident that it would be well to increase the bearing area of the joint-sleepers. This could be done by widening them ; but as it is very inconvenient in practice to have special sleepers of any description, we have tried the following simple method, which is found to stiffen and steady the road very considerably, especially when new and on a new bank. A sleeper is placed

FIG. 1

FIG. 2.

*Longitudinal Section.*

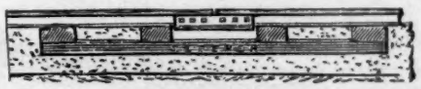


FIG. 3.

*Cross Section.*

longitudinally under the joint-sleepers, and notched to receive them, as in figs. 2 and 3.

Condemned sleepers can be utilized for this purpose, and on open lines, on which wooden sleepers are used, this tie-sleeper could be used at once, as there is doubtless a supply of sleepers in disuse from cracks, chair wear, and other faults, which would do very well for this purpose ; in fact, all could be utilized except those which are actually decayed from dry or wet rot ; but on most new lines the only sleepers available are those which are condemned under the specifications, and which can generally be had at a cheap rate ; these might be used in the worst parts of the line—that is, where the bank is likely to give trouble owing to bad soil, etc.

It would, however, in the interests of true economy, pay on new lines to use new sleepers (as well as condemned ones, if available) for this purpose, as the cost would be a mere bagatelle compared with the advantages and savings which would result therefrom.

The advantages attending this method are briefly :

1. The bearing or contact surface between sleepers and ballast under the rail ends is nearly doubled, and deflection of the joint-sleepers is prevented.

2. The joint fastenings are relieved of strains, and their life is prolonged.

3. The joint-sleepers are kept in their proper position, and, with some patterns of permanent-way, the creep of rails is prevented when such a tendency is set up.

4. A smoother and safer road.

There are many other minor advantages attending the use of this sleeper which practical railroad men will readily see.—*The Indian Engineer.*

**The Samara-Ufa Railroad.**—Great interest has been excited in Russia by the completion of the line from Samara to Ufa, on account of its being practically the first section of the future Siberian Railway. It is true that it is situated wholly in European Russia, not in Siberia, but the line was especially constructed, not for local purposes, but as a starting section of the Siberian communication with the river Volga and the railroads of Europe, and already the commencement has been sanctioned of the second section, situated in Siberia itself, stretching from Ufa to Zlataoust. The Samara-Ufa line extends from Samara on the Volga to the town of Ufa, at the foot of the Ural Mountains. The line differs from the northern Siberian Railway from Perm to Tiumen, *via* Ekaterinburg, in this important respect, that whereas the Perm line is totally unconnected with the Russian railway system, there being no line between Perm and Nijni-Novgorod, the Samara-Ufa Railway is in absolute touch with the entire railway system of Russia. In accordance with the new policy initiated by General Possiette, Minister of Ways of Communication, the line has been built by the State, and will be worked by Government officials. The line is 487 versts, or 325 miles, long. Its cost is estimated at 17,300,000 paper roubles, or 38,000 roubles ($19,000) per verst (⅔ of a mile), without rolling stock and rails, the latter costing 6,800,000 paper roubles, or 15,000 roubles ($7,500) per verst. The country for the most part is steppe—*i.e.*, flat prairie land, with few undulations. There is, however, a large bridge traversing the river Beirlie at Ufa, being 2,100 ft. long, divided into six spans of 350 ft. apiece. The constructor is V. S. Berezine, an assistant of Michaelousky in the construction of the Alexander Bridge (twice as long) over the river Volga at Sizran. Besides this colossal bridge there are 300 smaller ones, of which 11 range in length from 70 ft. to 210 ft. The whole of the materials used in the construction of the line are Russian, and no foreigners whatever have been employed in the undertaking. The number of stations on the line will be 25, or on an average one every 13 miles. This will show how slightly developed the country is. Only four small towns are touched on the way. When the Orenburg Railroad, in a parallel direction, was constructed a similar state of things prevailed, but numerous settlers followed the locomotive, and now the line is bounded by settlements throughout. It is expected that the same will occur with the Samara-Ufa line in due course. A great traffic is not anticipated until the line is pushed further into Siberia. According to current report the Government intends to construct the entire Siberian Railway itself, raising for that purpose loans from time to time, mainly in Russia. As industrial enterprise is very stagnant just now in Russia it is believed the public would readily subscribe to these issues of Siberian railway stock.

**The Ship Channel from Montreal to Quebec.**—An event of much interest to the people of Montreal was the official opening last month of the new St. Lawrence 27½-ft. ship channel from Montreal to Quebec, a distance of 160 miles. As early as 1825 this work had been spoken of and petitioned for, but it was not until 1838 that anything was really done.

From 1838 to 1867 the ship channel had been improved at various times, until at the latter date there was throughout the whole distance between Montreal and Quebec a minimum width of 300 ft. with a depth of 20 ft. at ordinary low water. Shortly after that the growing trade of the St. Lawrence and the increasing size of vessels demanded that the ship channel should be further deepened, and an act was passed by Parliament in May, 1873, authorizing the Government to contract a loan of $1,500,000 to defray the expense of completing the ship channel from Montreal to tide-water above Quebec to a depth of not less than 22 ft. at low water and a width of not less than 300 ft.

Operations were commenced in the spring of 1874 with one dredge and a stone-lifter, and contracts were entered into for the building of six large elevator or ladder dredges, and also for the purchase of tugs, scows and other plant required. The new plant was finished and set to work in the spring of 1875, and was kept steadily at work during the season of navigation of each year until the close of 1878, when a minimum depth of 22 ft. had been attained at all points except between Cap Levrant and Cap Charles, where it was necessary to take advantage of the tide. Up to that time there had been spent for new plant $523,902, and for working expenses $628,610, or in all, $1,153,512.

The channel in Lake St. Peter, the largest piece of dredging in any one place, is in all 17½ miles in length, 300 to 450 ft. in width, and involving the removal since the beginning of dredging in the present channel, in 1851 to 1882, of about 8,000,000 cubic yards.

No sooner had a depth of 25 ft. been reached than the Harbor Commissioners decided to prosecute the work still further, and in the following year, 1883, application was made to the Government and Parliament for a loan of $900,000 for the further deepening of the channel to 27½ ft. This was granted, and for the

past six seasons of navigation the work has been actively carried on, and it is now completed except at a few points, which can be finished by the time of low water next fall.

The growth, as shown in the following table, of the sea-going shipping trade at Montreal since the work of deepening from 20 ft. at low water to 27½ ft. was begun indicates the great increase in tonnage that the city may expect:

| | 1873 | | 1887 | |
|---|---|---|---|---|
| | No. | Tons. | No. | Tons. |
| Steamships | 242 | 245,237 | 600 | 807,471 |
| Ships | 72 | 65,823 | 7 | 8,684 |
| Barks | 164 | 75,594 | 68 | 43,275 |
| Brigs | 18 | 4,660 | 2 | 1,118 |
| Brigantines | 59 | 8,581 | 7 | 2,031 |
| Schooners | 149 | 12,583 | 83 | 8,194 |
| Totals | 704 | 412,478 | 767 | 870,773 |

It has been demonstrated that the tonnage of a port will increase as the cube of the depth that can be carried in. The depth of 27½ ft. has only just now been attained, and its effect on the trade of Montreal is yet to come; but next year Montreal may expect to have or to exceed a million tonnage.

**A Swiss Electric Railroad.**—The electric cable railroad up the Burgenstock in Switzerland is interesting to electricians and engineers because of the novelty and skill which have entered into its accomplishment, and because of the extraordinary difficulties which have been surmounted. Hitherto it has been considered impossible to construct a funicular mountain railway with a curve, but the new line up the Burgenstock has achieved that feat under the superintendence of Mr. Abt, the Swiss electrical engineer. The rails, in fact, describe one grand curve formed upon an angle of 112 degrees, and by an arrangement of wheels for the cars known as the "System Abt," the journey is made as steadily and smoothly as upon any of the straight funiculars previously constructed. The Burgenstock being almost perpendicular, it would have been impossible to construct a railway upon the old plan. A bed has been cut for the most part out of the solid rock in the mountain side from the shore of the Lake of Lucerne to the height of the Burgenstock, 1330 ft. above its level, and 2,860 ft. above the level of the sea. The total length of the line is 938 meters, and it commences with a gradient of 32 per cent., which is increased to 58 per cent. after the first 400 meters, and this is maintained for the rest of the journey. A single pair of rails is used throughout, with the exception of a few yards at half distance to permit the two cars to pass. Through the opposition of the Swiss Government, each car is at the present time only allowed to run the half distance, and they insist upon the passengers changing, in order, they say, to avoid collision or accident.

The current is generated by two dynamos, each of 25 H. P., which are worked by a water-wheel of 125 H. P., erected upon the river Aar at its mouth at Buochs, three miles away. The current is conducted by means of insulated copper wires to a pair of electric motors, of the same power, which are placed at the head of the railway. The loss of energy in transmission is estimated at 25 per cent. The motors are connected by leather belting with two large pulleys on a countershaft, which is connected with a set of movable conical cogs, from which the big wheel over which the wire rope passes is driven. To give the rope adhesion it is wrapped under and over two smaller pulleys, and then for a second time over the larger wheel. The arrangements for applying the power are of the simplest character. Only one man is required to manage the train, and the movement of the cars is completely under his control. One dynamo is sufficient to perform the work of hauling up and letting down the cars containing 50 or 60 persons. With a switch the conductor regulates the amount of current according to his requirements. He communicates by electric signals with the man at the water-wheel when the cars are about to commence their journey, and the latter in turn regulates the water-power applied. A finger moving along a figured disc before him, by means of a millimeter screw, at the rate of a millimeter to every meter of the railway enables him to see the exact position of the cars on the line at any given moment of the journey, and he can increase or slacken speed accordingly. In addition to this the cars themselves give him a signal at stated points. For instance, at a distance of 1 meter and 15 meters respectively after the car leaves either the upper or the lower station, the flanges of the wheel pass over an electric plate, and a bell is rung in the machine-room. The same signs are given when they arrive within 15 meters and 1 meter of the half distance, so that the cars are themselves their own signalmen, and the driver knows exactly when to shut off power. At the end of the journey, completed in about 15 minutes, at an ordinary walking speed, the car moves gently against a spring buffer, and is locked by a lever without noise and without jolting the passengers.

The interesting undertaking has been carried out at a cost of $125,000. The water-wheel is also employed to light the whole of the hotel buildings and its grounds by electricity, and when the railway is not working, another dynamo pumps up spring water 1,000 ft. for use in the establishment.

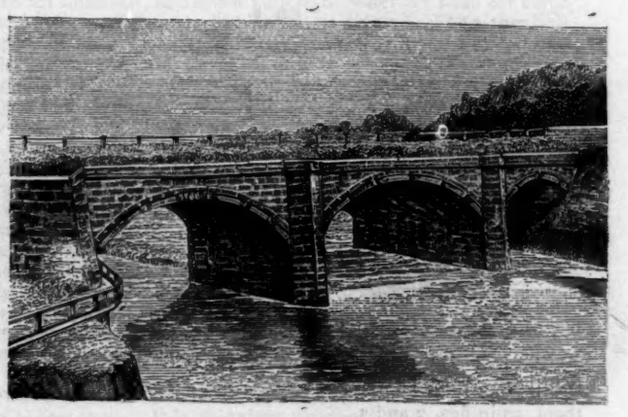
The motors derive their current from a set of accumulators at the station and not directly from the dynamos. This arrangement has probably been adopted not only for the sake of economy in the mains, but also to avoid possibility of accident arising from an interruption of the charging circuit.—*London Electrician.*

**A Historic Bridge.**—The Barton Aqueduct, which, in its day of completion, was the subject of awe and admiration of kings and princes, is now to give way before the Manchester Ship Canal, a yet more important undertaking, which increased and ever-increasing population and commerce have rendered desirable.

In 1757 the Duke of Bridgewater's attention was turned to the question of a waterway from the Worsley coal-pits on his Lancashire estate to Manchester. His first serious consideration seems to have been the difficulty of crossing the river Irwell. His first idea was to reach the ordinary level of the river by means of locks, but he finally decided the loss of time and the additional cost of working the canal traffic was too great.

The Duke secured the services of James Brinkley, an ingenious, honest and hard-working millwright, who advised him to abandon the idea of locks altogether and to carry the canal at one uniform level throughout. The proposition was so original and stupendous that we are surprised to find the Duke willing to listen to such a suggestion. But so great was his faith in Brindley that, in spite of the work entailed, we find that he again introduced a Bill before Parliament to extend his powers and enable him to construct the present aqueduct. This Bill passed in 1760, and the work was at once begun and actively pushed forward.

The Barton aqueduct, as will be seen from our sketch, consists of three semicircular arches, the center one having a span



of 63 ft. The total length of the aqueduct is about 600 ft., and the average width 36 ft. This aqueduct, which is shown in the accompanying illustration, is of interest, not only from the excellence of design, but from the fact that when it was built it was the only large canal bridge outside of China.

The new ship canal contract includes the removal of the whole of the three arches and the construction of a new aqueduct on a slightly different line. The difference of level between the Bridgewater Canal and the proposed shipway is 32 ft., the level of the Bridgewater Canal being unaltered, and that of the ship canal being 7 ft. higher than the old level of the river. It will be easily understood that, although a total height of 39 ft. was quite sufficient for the old barge traffic navigating the Irwell, it would be quite impossible for sea-going vessels to pass. To meet this difficulty Mr. Leader Williams, the Engineer of the Ship Canal Company, has designed a swinging caisson for the high level barge traffic, so arranged that when a vessel is about to pass up or down the ship canal gates are closed at each end of the caisson. This being done, the caisson becomes practically a detached portion of the canal, and is readily turned on its center, thus leaving an uninterrupted shipway. Provision is also to be made at each side of the new waterway for raising and lowering barges from and to the ship canal. For this purpose hydraulic lifts will be employed. At present the contractor, Mr. T. A. Walker, has not begun the construction of the new aqueduct, but the sections immediately above and below the bridge are being steadily pushed forward, and the scene on either side is one of great interest and activity.